British Carbon Group Newsletter—August 2004

Editorial

The main purpose of this newsletter is to inform you officially of the Group AGM on September 30th at the Institute of Physics: the agenda of the AGM and the minutes of the 2003 AGM are included. It will be preceded by a meeting of general interest called Foresight Carbon, provisional details of which you will also find later. Please try to come if you can. As we did last year, we are using the newsletter to publish the minutes of the AGM for 2003 together with the meeting notice and agenda, thus saving our hard-working Secretary from having to pass round piles of unnecessary paper at the meeting itself.

We had a very successful Spring meeting at Aberdeen, the second in the series of workshops on adsorption on microporous carbons. There is still sufficient interest in the topic to enable us to consider another follow-up meeting, possibly back-to-back with Carbon 2006.

That leads me to how progress is going with this very important meeting and I am glad to report that things are moving well. Tony Wickham confer@globalnet.com has been appointed as Conference Manager and has been hard at work putting things in place. With only 2 years to go, your committee has had to take a lot of decisions already and we include a progress report in the newsletter.

There are two or three other meetings that the Group is organising or associated with taking place at about this time, of which you had notice in our last issue and I hope that accounts of these will appear in the next.

One potential meeting in 2005 for which response was somewhat muted is that proposed for Istanbul. We are inserting a further notice here to encourage you to express interest, otherwise sadly, we shall have to abandon what could be a very interesting and worthwhile collaboration with our Turkish colleagues.

On more general matters, this issue will have a somewhat glittering appearance in its concentration on diamonds. There seems to be a lot of activity in this area, including a meeting on the subject at Lago di Garda, Italy next month: I am particularly grateful to Jon Goss, a member of our committee, for his contribution. We are trying to encourage workers in this field to realise that they are dealing with the element close to our hearts and that the Group has much to offer them. Like all editors, I should be only too grateful for any other offers of contributions from our membership, or indeed, from outside it.

Welcome back also to our SCI members. John Fisher has negotiated a deal whereby the SCI has promised to collect subscriptions for a trial period.

Norman Parkyns *norman.parkyns @tesco.net*

The British Carbon Group

Notice of 2004 Annual General Meeting

Notice is hereby given that the 2004 Annual General Meeting of the British Carbon Group will be held at the Institute of Physics, 76 Portland Place, London at 6.00 p.m. on 30th September 2003, following the "Foresight Carbon" meeting (details given below).

The business of the Meeting is as follows: -

1. Apologies for Absence
2. Minutes of the previous AGM (held at University of Sussex, Brighton, 28th. August 2003)—*appended below*
3. Matters Arising
4. Chairman's Report
5. Treasurer's Report
6. To Receive Notice of the Representatives to the Sponsoring Bodies
7. Election of Officers and committee member.
8. Any Other Business **previously notified in writing to the Hon. Secretary before 23rd. September 2004.**

At the 2004 AGM the Chairman, Vice Chairman, Secretary and Treasury must stand down and offer themselves for re-election. Other nominations for these positions are invited. In addition two ordinary positions on the Committee fall vacant this year and nominations for these positions are invited.

Nominations, duly proposed and seconded and with the consent of the nominee, should be received by the Honorary Secretary before 23rd. September, 2004 at the following address: -

Dr. J. Fisher
UCAR Ltd.,
Claywheels Lane,
Sheffield.
S6 1NF

Tel: 0114 2852233
Fax: 0114 2338387

e-mail john.fisher@graftech.com

THE BRITISH CARBON GROUP

MINUTES OF THE 2003 ANNUAL GENERAL MEETING HELD AT THE UNIVERSITY OF SUSSEX, BRIGHTON, 28th AUGUST, 2003 AT 6.00 pm

PRESENT: Dr M.I. HEGGIE, Acting Chairman; plus 9 members.

APOLOGIES FOR ABSENCE:
Apologies for absence were received from:
Prof. B. McEnaney, Dr. N. Parkyns, Prof. J. Patrick

MINUTES OF THE PREVIOUS MEETING

The minutes of the previous AGM, held on the 10th April, 2002 at the Robert Gordon University, Aberdeen were approved as a true record.

ACTIONS AND MATTERS ARISING (not covered in Agenda)

The unapproved 2002 minutes were published in the summer 2003 Newsletter, as suggested by Dr. Mays. The intention (subject to committee approval) would be to publish 2003 AGM minutes in a similar way.

CHAIRMAN'S REPORT (Dr. A.J. Wickham)

This is my final report as Chairman of the Group and covers the period from April 2002 until the end of March 2003 at which point I resigned leaving you in the very capable hands of Dr. Malcolm Heggie as Acting Chairman. My original intention had been to stand down in an orderly fashion at the AGM which was scheduled for April 2003 during the Spring meeting at Leeds University. In fact, this scheduled AGM had to be cancelled because it was not advertised to the membership as required by our Statutes, and this is an example of one of the contributing reasons whereby I decided to stand down.

I have become increasingly aware that, as a Group committee, we have consistently failed to deliver (in my opinion) the quality of service to which our membership can reasonably expect to be entitled. In the first year of my term of office we actually cancelled an entire meeting because the committee members at the time who agreed to organise it failed to do so. More recently, we failed completely to issue the December 2002 newsletter until July 2003, through no fault of the editor I need to stress. As a result of that, we failed to advertise our Spring 2003 meeting (which was a joint meeting with the RSC Energy Sector) *and* the AGM – hence the cancellation of the latter. The only redeeming feature of that episode was that the Energy Sector failed to advertise it to their members as well until the very last minute. The result was a meeting curtailed from two days to one and with a very low attendance, although in fact it made a profit because the Energy Sector side insisted on retaining rather high fees for the reduced meeting, making it even less attractive in my view to those members who had somehow managed to find out about it.

As a result of these things and one or two others, I concluded that I was not succeeding in leading the Group in expanding its activities, as I had hoped, but seemingly rather the reverse, and therefore it seems appropriate to allow others the opportunity to do better. I confess also to another need, on my part, to relinquish the trusteeship of the Group which the Chairmanship confers, and that is related to the desire of my conference management organisation to seek a commercial arrangement with the Group over the forthcoming international carbon conference, so it is not entirely gloom and doom which leads me to the resignation position.

So, let's turn to the good news. We held an excellent Autumn meeting in 2003, although it was held in the late summer instead, and that was NanoteC'02. This was a joint meeting with the French Carbon Group and was a considerable success, as is its successor meeting this year NanoteC'03 for which there are 87 registered delegates plus an uncertain number of Harry Kroto's students dropping in at mealtimes and contributing significantly to the discussion (so why not!). I think that the NanoteC series has become large enough now to run and run, and I hope that holding it in France next year as we have agreed with the French group to do, and changing the time of year to October, will not disturb the flow too much.

The Spring meeting on "Carbon in Energy Applications" at Leeds, to which I referred earlier, produced diverse topics of considerable interest I think, and was enjoyed by the very few of us who attended.

A few members, sadly excluding myself this year, attended the International Carbon Conference in Oviedo which was also a success.

Looking ahead, we are following up on the Porous Carbons Meeting held at Aberdeen in Spring 2002 with another one this coming April, and these meetings too are strong enough with a significant international contingent to become a self-supporting series every other year.

My demise as Chairman does not signal a withdrawal from Group activities, since I am already organising a joint meeting with the Turkish carbon scientists to be held in Istanbul in 2005 and for which I am counting on strong support from the UK side. The subject will be "Precursors to Carbon Materials" and it will include a trip on the Bosphorus (which I recently tried out and it is stunning) and a trip to Topkapi Palace – oh, and there may some scientific sessions too. Looking further ahead, I have had some hand along with our colleagues in Aberdeen in organising the things which need to be organised at this time for the next Europe-based International Carbon Conference in 2006 and I hope to continue that involvement.

So, I wish the Group and its next Committee continued success, but I urge it to spend some time contemplating its navel and thinking about change before slipping into a higher gear and bringing it about. The problems I've outlined with committee failures have been matched by an almost total inactivity on the part of our ordinary membership – possibly *the* key reason why the Group currently seems to be lurching along rather erratically. We need to involve far more people in organising and supporting our activities and, if our current ideas don't achieve that, then they are probably the wrong ideas.

Finally, it is appropriate to thank the present Officers and Committee for their work, especially those involved in the organisation of our successful events and the contributors and editor of the newsletter.

Response by Dr. Heggie

Dr. Heggie responded to Dr. Wickham and thanked him for his extremely valuable contribution to the BCG, both as chairman and in his previous positions. Dr. Heggie said that Dr. Wickham's self-criticism contained in his report was totally unjustified and other members present echoed this opinion.

TREASURER'S REPORT

Some payments had not cleared by the end of the financial year, however for clarity they have been added to the 2002 accounts. These cheques totalled £10,933.61.

Balance at the beginning of the 02 financial year was **£32,633.55**

Total Banking for the Year was	£10,847.77
Less Payments for the Year	£16,154.92
Final Balance at end of 02 financial year	**£27,326.40**

Therefore the account decreased by £5,307.15 during the year.

Three external subscriptions were made during 2002 and in addition a large number of members joined as a result of the NanoteC02 conference and Aberdeen Workshop. A database of members not funded through relevant societies has been compiled and a letter will shortly be sent to those people asking whether they wish to renew their subscription.

NanoteC 02 conference more or less broke even and a number of travel bursaries were given totalling £555. Income from the conference was not all collected in the financial year and a further £1,253 should be added in order to give an indication of the accounts for the year.

Aberdeen Adsorbents workshop, the workshop made a loss of around £2000 however since the publishing of the 2002 accounts a further £500 in outstanding payments has been added to the accounts and in addition not all of the allocated expenses have been utilised adding a further £500. Therefore the loss from this conference is only in the order of £1000.

The income of the Brian Kelly fund is now in the order of £12,813. Income for the fund was around £680 however expenditure was £1,043 as two Brian Kelly awards were presented at the Carbon 2002 Conference.

A small amount (£242.85) was spent on the upcoming Carbon 2006 conference

As noted above the balance of the BCG accounts decreased by £5,307.15. However, with the added income from the Aberdeen workshop and the additional income from the NanoteC conference this now stands at £3,054.15 and is in accord with the Committee's policy for decreasing the account balance.

Election of officers and Committee members

The following officers and committee members had retired or were retiring or stepping down at the 2003 AGM.

Dr. A.J. Wickham	- Chairman
Dr. M.I. Heggie	- Vice Chaiman
Professor B. McEnaney	
Dr. T. Hutton	
Dr. T. Mays	- IOP Representative

The following were elected unopposed.

Officers :

Chairman:	Dr. M.I. Heggie (University of Sussex)
Vice Chairman:	Professor J.W. Patrick (University of Nottingham)

Committee Members:

Dr. S. Mikhalovsky
Dr. A. Westwood

The following were appointed as representatives of the sponsoring bodies:

SCI representative	Professor R.H. Bradley	(Robert Gordon University)
RSC representative		
IOP representative	Dr. J. Goss	(University of Newcastle)

Any Other Business

There being no other business the meeting was closed at 18:45.

Foresight Carbon

Institute of Physics, 76, Portland Place, London, Thursday September 30th 2004

Carbon is a unique element and exceptionally diverse in its technological applications, from heavy industry (as an electrode material), to sport, car racing and aviation (carbon fibre reinforcement and carbon in carbon composite brake material), to nuclear reactors (moderator in fission reactors, first wall material in fusion reactors)... and that is just the black stuff! The man and woman on the street know of the unique value of diamond, and possibly of its extreme hardness, chemical inertness, thermal conductivity. The up and coming class of materials launched initially by the discovery of Buckminsterfullerene and boosted by the discovery of carbon nanotubes could possibly ultimately dominate the applications of carbon. At this meeting there will be an afternoon of talks from several leading UK scientists who will offer their views of the future applications of carbon.

The scientific meeting will be followed by a reception and AGM courtesy of the British Carbon Group. We encourage all our members to come along, listen, meet the Committee and put their views about the future directions of carbon research. Please note that from time to time, our sponsoring professional/scholarly institutions - the Institute of Physics, the Royal Society of Chemistry and the Society of Chemical Industry - are consulted by government on scientific foresight, and this is your opportunity to feed them your views through the British Carbon Group.

Provisional timetable:

14.00 *Welcome* (Professor Malcolm Heggie, Chair British Carbon Group)
14.10 *Realistic applications of nanotubes*
Professor John Robertson (University of Cambridge)
15.00 Questions/Discussion
15.20 *The RAE-Royal Society report on Nanotechnology – a personal view*
Dr Nicole Grobert (University of Oxford)
15.40 Questions/Discussion
16.00 *Quantum computing with nanotubes* (speaker from University of Oxford)
16.50 Questions/Discussion
17.30 Reception and AGM.

Please consult the web for the latest programme -www.britishcarbon.co.uk. It would be very helpful if anyone wishing to come could signal their intention to do so to M.I.Heggie@sussex.ac.uk but feel free to come along anyway!

2nd Symposium on Adsorbent Carbons
The Robert Gordon University, Aberdeen 28-29 April 2004

This meeting was a follow-on from a first meeting held in April 2002 at RGU. The format was the same as the first in that one-hour keynote lectures set the themes for individual sessions in which the speakers were allowed thirty minutes. This slightly longer time was designed to allow for the development of more in depth discussions of the precise content of presentations but it also allowed some consideration of broader issues, fundamental and practical, related to some of the points addressed.

Invited speakers were Professor Fritz Stoeckli, from the University of Neuchatel, who gave us an update on' *Recent Advances in Dubinin's Theory of Adsorption'* and Dr Tim Burchell who spoke on '*Porous Carbon Fibre Composites for Natural Gas Storage* '. Unfortunately, due to a last minute 'change of employer' Fred Baker was not able to attend and deliver his planned lecture on *'Industrial Aspects of Carbon Adsorbents* '. I filled the 'grave-yard' shift (4.00-5.00 PM on the first day) with my lecture covering aspects of *'Surface Science Techniques used to Study Adsorption and Carbon Surfaces* '.

The meeting was well attended with a total of 30 delegates. These came from as far as Mexico, Switzerland and the USA as well as south of the border. Surface Measurement Systems and Hiden-Isochema sponsored the event, and we thank them for their support. In all, nine lectures and two posters were presented and, as at the first meeting, healthy discussion followed most of the presentations with a few old chestnuts such as: the origin, development and nature of porosity in carbons; states of adsorbed phases and some of the thermodynamic definitions which are used in the study of adsorption, all being discussed.

As a personal note, I tried to take a backseat in the organisation of this meeting and to get more involved with the science, hence my own contribution to the programme. I would like to thank Tony Wickham for dealing with registrations and Christine Gray who did most of the 'other things' as usual with high efficiency and minimal fuss. Everyone that I spoke to said that they enjoyed the two days and found something on the programme to justify their visit. The challenge of hosting any scientific meeting is surely in providing the appropriate framework to bring scientists together in the first place. Once the discussions begin they will carry on well outside the formal sessions and I am pleased to say that is what happened this time. I enjoyed listening and I enjoyed taking part.

Bob Bradley

As Editor, I should like to use my privileged position to add a little to Bob's report. As one of the delegates, I must say that I much enjoyed this meeting, which was big enough to be viable but small enough to ensure that all the delegates could chat informally and

productively during the various breaks. The size of the meeting also made for very good discussion after all the research papers. My own contribution was the only one to use what my son, who is in the IT business himself, refers to approvingly as “stone-age technology” in that old-fashioned overhead transparencies were used to convey the message. Everyone else used PowerPoint of course! Tim Burchell gave an interesting account of work on Adsorbed Natural Gas at the US Department of Energy, referring to me as a leading expert in the field, which caused me to blush modestly in the back row of the lecture theatre. I also met an old friend and former colleague, Don Carruthers, whose firm has a very interesting method of supplying hyper-pure compounds of silicon and other elements to firms in the semi-conductor industry. Apparently, the best way is to deliver them adsorbed onto activated carbon and one of the best carbons for this purpose is a PVDC-derived carbon that David Quinn from the Royal Canadian Military College developed for use in ANG.

The meeting was used as a dummy run for Carbon 2006, in that Tony Wickham handled the administration and enabled some of us to have a look at the facilities likely to be used. There is no doubt that Aberdeen, and the Robert Gordon University in particular, is well placed to handle the larger-scale meeting. ` ndp

"Precursors for Carbon Materials"

> The planned joint meeting with the Turkish Carbon Group in May 2005 was announced in the last newsletter and the announcement is repeated below. Response has been negligible, which is extremely disappointing. Tony Wickham still hopes to have a viable number of committed delegates to make this happen, and you are invited to contact him immediately with expressions of interest and short abstracts. He intends to impose an absolute cut-off date for deciding on the viability of the meeting, which will be October 29th 2004. If the meeting then goes ahead, those planning to attend will be asked to make a non-refundable cash deposit as a guarantee of their commitment, which will later be deducted from the costs of the registration fee when that is collected. Once again, this is potentially a superb trip both for delegates and accompanying persons, and our Turkish friends can be relied upon to organise a memorable time for all.
>
> Incidentally, *all* carbon materials - composite, nanotubes, whatever, are eligible!

A meeting is being proposed in Istanbul, Turkey in April or May 2005. jointly between the BCG and its Turkish counterpart but we hope for significant representation from other European carbon groups.

Tony Wickham will be arranging the details with Ferhat Yardim in Istanbul. As the topic is "Precursors for Carbon Materials", we have decided that this should include all carbon materials, including nanotubes. The springtime date should not affect any plans for Nanotec 05 to be held later in the year. The basic arrangements will be that the meeting is open to all interested participants from any country. Turkish colleagues will be responsible for local arrangements and for handling registrations and fees for Turkish participants while Tony will be responsible on behalf of the British Carbon Group for registration for all non-Turkish participants.

In addition to the technical programme there will be a cruise on the Bosphorus and a trip to Topkapi Palace. We encourage delegates to consider bringing their partners, for whom our Turkish colleagues will organise a special sightseeing programme. Travel to, and within, Turkey remains very cheap.

However, the hosts are asking us to guarantee a certain minimum numbers of participants before they can go ahead with the arrangements. Tony needs to have expressions of interest, offers of presentations (usual 20-minute variety, some perhaps longer) -either oral or as posters, so that we can assess whether the meeting is viable. Please contact him as soon as possible on confer@globalnet.co.uk.

Progress on Carbon 2006

Quite a lot of things have fallen into place now and the meeting is taking shape. The main point of interest is that the Committee has received a tender from Tony Wickham to manage the conference and after careful consideration, decided that no better person could be found. (It does look to me as though I could have put the foregoing more positively. As it is, it reads rather like these ambiguous testimonials of the "you will be very lucky if you get this man to work for you" type. I can only say that we really do believe that Tony's unique experience in the carbon field and his management of the Newcastle meeting in 1996 do give us confidence that we have the right man for the job!).

Chris Ewels has put in a preliminary Carbon 2006 Website at www.carbon2006.org that he says is big on tartan, and loaded with whisky and golf but the form for registering for info now goes to Tony, following the above decision.

We are considering having a large marquee in the quadrangle, which RGU have been used to having for degree ceremonies. This would have the advantage of having many more of the Conference's peripheral activities under one roof. Negotiations are in hand as to the feasibility of this. All the lectures and scientific part of the programme will be within easy reach, an important consideration when one has multiple parallel sessions.

We are inviting various distinguished figures in the field of carbon to assist with our International and Programme Committees and a small group under Prof. Bob Bradley to handle the important matter of social and other support events has been set up. We've had very good cooperation with the local Tourist Board and of course, the Robert Gordon University, so the basic requirements of accommodation are being met with a range from student budget rooms to the best hotels that Aberdeen city can provide.

Current Progress on making and using artificial Diamonds

Diamond is a form of pure carbon that has been associated with extremes into antiquity. The saying goes that diamonds are forever, but since diamond is only a metastable form crystal form of carbon under atmospheric conditions, they most certainly are not.

The metastability of diamond under normal conditions causes problems in its synthesis, but has lead to ingenious industrial solutions that mimic the geological environment from which 'natural' diamond is born. In the earth's crust the temperature and pressure is rather higher than on the surface, and one can simulate these conditions in a pressure cell in order to replicate the natural growth environment. Since we can't wait geological time-scales for manufacture, diamond synthesis is achieved at very high temperatures, and the growth rate then leads to some tell-tale differences between these synthetic stones and those dug out of the ground.

In practice, diamonds are grown using a catalytic reaction of graphite onto a diamond seed, the catalyst being a mixture of transition metals and occasionally other chemicals to 'dope' the material and give it electrical conductivity or colour. Carbon dissolves in the metal and is transported to a growing carbon-crystal surface. At growth temperatures and pressures the most stable form of carbon is diamond rather than graphite, so the reaction proceeds in the desired direction and large, single-crystal samples can be obtained. The quality of the material is dependent on the precise cocktail of solvent-catalysts used, and to some extent on the seed crystal. For instance, diamond can contain large concentrations of some impurities, and in particular nitrogen and boron. The latter leads to technologically-useful conductive material, but nitrogen does not. Indeed, depending on the specific arrangement of nitrogen in the diamond lattice, the colour of the diamond can vary from clear (or what is termed white) to yellow or even brown, just by the incorporation of nitrogen. The colouration is typically undesirable in gemological terms, but the uptake of nitrogen in the lattice can be reduced by the addition of nitrogen "getters" in the solvent, such as zirconium.

It is interesting to note that the solvents themselves do not in general become incorporated in the diamonds grown via the high-pressure and temperature method, with the exception of cobalt and nickel. Why these species are taken up by the growing diamond and not others such as Fe which is commonly used in the catalyst, is not clear.

Despite the metastability of diamond under ambient conditions, there is an alternative growth method which does not rely on high pressures and temperatures. Indeed, from a commercial materials viewpoint, this second approach is much more practical. Diamond, like many other crystalline materials, can be grown using an excited gas. For diamond, the gas must, of course, contain carbon, and the vast majority of growth also involves hydrogen, although diamond can be grown without it. In fact there is typically much more hydrogen in the gas than carbon, with the excitation (typically in a plasma) breaking up the molecular source species into radicals that can attach themselves to a substrate.

As with HTHP diamond growth, the initiation is extremely important. Surface preparation is a science in itself, but one can caricature the growth scheme subsequent to this initial stage as the addition of hydrocarbons to receptive sites on a diamond surface. A key question is why this might result in carbon linked in four-fold bonding rather than three-fold bonding schemes?

The current models for diamond growth from hydrogen/hydrocarbon gases involves the hydrogen in removing material from the surface. When the parameters of the growth chamber are chosen correctly, the removal of material is faster for non-diamond bonded material, and provided that the incorporation of carbon into the lattice is faster than the hydrogen etching, diamond films result. By varying the growth parameters a continuous range of carbon-networks can be formed, from 'pure' diamond to amorphous carbon, and the composition has a profound influence on the appearance, electrical and mechanical properties of the material.

In contrast to the 'lumps' of diamond, recognisable as something you might find in jewellery, diamond grown from the gas phase is typically in the form of a film, although rather thick films can now be grown. Most commonly the films do not constitute a single continuous crystal, but are formed from a plethora of small crystallites which interconnect in a complex fashion. The nature of the films vary considerably in terms of the size of the diamond crystals, their orientation with respect to the growing surface and each other, and the amount of non-diamond material caught up in the film. Depending on the quality of the film, it can appear black or white, or even coloured where other impurities are present.

The film geometry lends itself to microelectronic device manufacture, and much effort is being directed at the optimisation of the electrical characteristics of poly- and single-crystal diamond films grown from the gas-phase. In addition to the geometry, the very atomic mechanisms of growth allow for different chemicals to be incorporated into the material than in the HTHP scheme, with phosphorus and sulphur being used in addition to boron doping.

Additionally, since plasmas flow around complex shapes, diamond can be used as a coating material, taking advantage of the extremely favourable wear and friction characteristics. Coatings can be found in the mundane, such as long lasting razor-blades and scratch resistant sun-glasses, to potentially life-altering medical applications such as hip-replacements and other bio-compatible medical systems.

Commercial manufacture of diamond remains a relatively small fraction of the total volume of diamond production world-wide, but this may be set to change with manufacturing plants for both HTHP and gas-phase material being established. As the materials become cheaper to produce and as the technological applications such as high power electronics are realised through the optimisation of the electrical characteristics of doped diamond, it seems likely that a material popularly only considered as an expensive play-thing will become widespread in the home and industry.

J.P. Goss

(I am grateful to Jon Goss for providing this authoritative overview of the current progress in making artificial diamonds. I actually received it after I had written the account of the Horizon TV programme given below, so you should read that with this in

mind. Jon actually answers some of the queries I raised but I've let it stand. My knowledge of this subject is little more than the average physical chemist's, so you may take this little article as being a quasi-layman's view. He was also good enough to comment on my article and his remarks are given at the end of the latter. ndp.)

Diamonds are forever?

You may remember that I wrote an account of a BBC TV Horizon programme about artificial diamonds (Newsletter November 2000). Recently, they returned to the topic with another fascinating update about progress in this field. There was inevitably quite a lot of overlap with the previous programme that started with a recap of the classic work of the General Electric work of the late 1950s that resulted in the first definite artificial diamonds. They had to use pressures up to 60 kbar and temperatures of around 2000K to get into the range where diamonds are the preferred stable form of carbon and even then, they achieved success only by incorporating an iron sulphide catalyst. The picture of the 400 tonne press was very impressive, all the more so when the programme moved on to describe the much more recent Russian work which was done on a shoe-string, relatively speaking.

Dr Feigelson, the Russian worker featured here had devised a very cunning and compact tetrahedral anvil press that got up to 58 kbar. Unlike the earlier GE work which produced small but commercially useful diamonds suitable only for cutting and grinding purposes, Feigelson made quite large single crystals. Not only that, but he was fortuitously making light yellow-coloured diamonds that attract enormous prices as gemstones when found naturally. Suddenly, everyone was beating a path to his door. As told in the earlier programme, General Carter Clark, an American entrepreneur, now entered on the scene and took the whole of the Russian work to Florida where it re-emerged as the company, Gemesis. They had problems in scaling-up to a consistent commercial production but this problem was overcome by applying a computer control to all stages of the synthesis and they were soon churning out these very attractive yellow-coloured diamonds. They had 23 production units and were able to make up to 3-carat stones, which sold for a quarter of the price of their natural counterparts: Clark had plans for a ten-fold expansion.

De Beers had initially been worried about the possibility of the market being flooded by synthetic diamonds that were indistinguishable from the natural stones but research in their London labs. had shown that under UV radiation, each type of diamond had a characteristic fluorescence pattern, set by the type of nitrogen defects that cause the yellow colouration. Thus, natural diamonds could readily be detected from the synthetic. As Clark was not in any case attacking their market of natural stones but was aiming at people who would normally not be able to afford diamonds like these and as he could not make the clear colourless diamonds that were the mainstay of de Beers' income, they could afford to take a relaxed attitude to the upstart.

Enter with a roll of thunder, stage left, Dr. Robert Linares of Apollo Diamond. He is going to upset the apple cart in a big way. He got into the synthetic diamond business via semiconductors. He explained that diamond has a most desirable combination of extreme

mechanical hardness, excellent thermal conductivity and potential for semiconductivity. Single crystal diamond of the right shape would be, according to him, the next big semiconductor material. His approach to synthetic diamonds was totally different to the GE and Russian work. He used CVD with a mixture of hydrogen and methane from which carbon was deposited at 800^0C from a microwave plasma at low vacuum pressures. Yellow diamonds of 15 μm thickness were used as seed crystals on which diamond is grown, presumably by epitaxial growth. Dr. Linares claimed that they could make flat clear diamonds of up to 5 mm thickness that could not be distinguished from natural stones.

At this point, the programme went a bit out of focus scientifically speaking, understandably perhaps, because half of America must be trying to replicate this work. There was some talk about an experiment that lasted over the weekend that mysteriously gave them this large clear diamond. We then had some images of what might have been a diamond being agitated under a clear liquid in a flask, although whether this was an integral part of the process or just made good, but irrelevant TV pictures, was not explained.

The impact of this new work on the gem diamond market remains uncertain. According to de Beers, they can distinguish these new clear, synthetic diamonds by their UV fluorescence pattern. This is well and good for the big, really valuable stones but as the programme pointed out, if you have diamonds worth less than £1000 in value, which is where the big market is, it is highly unlikely that these would ever be submitted to the expensive fluorescence test. It ended with the disquieting aspect (from de Beers' point of view at any rate) that the whole gem market could be infiltrated by synthetic stones that could be made at a fraction of the cost of natural diamonds.

Norman Parkyns

Just to get an expert view, I had sent a copy of the above to Jon Goss and he commented as follows.

"As for the document you sent to me regarding the Horizon programme, I have only a small comment. There are two kinds of "yellow" diamond. They are usually termed fancy yellow if they are the rare, highly coloured variety which fetch huge sums of money, and constitute one of a few colours that occur naturally, others being blue, green, and red. Then the other kind of yellow diamonds are part of a range of "off-white" yellows, mainly indicative of nitrogen but also plastic deformation, which generally detract from the value. Indeed there is a gemological range of colours (denoted D-Z by the GIA, representing from white to increasing colour). The less white usually means the less valuable.

Most diamonds grown via the pressure cell method are nasty yellow unless you take steps to stop the incorporation of nitrogen."

Nanotubes have wings!

As I was watching the above programme, I was a little concerned about the thermodynamics of the CVD process. Even if you have epitaxial growth on a diamond

surface, surely there would be a powerful driving force for the deposited carbon to revert to the stable form which at sub-atmospheric pressures and 800^0C is graphite, or of course, fullerenes and nanotubes. The whole idea of facile growth of diamonds on a bulk scale using CVD is too good to be true and I guessed that Apollo Diamond were being very coy about the exact conditions of preparation because half of America would be trying it out.

I was discussing this with Chris Ewels after a committee meeting and he agreed that there was a lot more in this process than met the eye. He sent me a copy of an interesting paper that he and his colleagues had just published[*]. They had made nanotubes in a more or less conventional way but had then exposed them to an Ar/CH_4 microwave plasma at 800^0C with the hope perhaps of depositing diamond-like structures. Instead, the outer skin of the nanotubes was ripped apart and "wings" of graphitic-like structures were grafted on or possibly derived from the opened–up carbon atoms. You will realise that these conditions are very close to those used in the Apollo Diamond synthesis of macro-scale diamonds but this time a graphitic structure, rather than diamond, is produced, rather more in accordance with what thermodynamics might suggest.

Chris and his colleagues surmise that C_2 is produced in the plasma and is necessarily accompanied by hydrogen. They think that this latter in atomic form is the agent that opens up the outside of the multi-walled nanotubes and allows the graphitic wings to grow. In diamond synthesis, a higher concentration of hydrogen saturates the dangling carbon bonds, converting them into the sp^3 configuration characteristic of this allotrope.

It could well be therefore that there is a narrow range of conditions that lead to diamond synthesis by CVD from methane/hydrogen and Apollo have been fortunate to hit them. One can only suppose that there is a lot of frantic activity going on in the World to crack this particular nut!

European Carbon Association meeting

Informal notes of the meeting made by Malcolm Heggie on Monday 12th July, 6.30pm, Brown University.

Present: Wolfgang Klose (Chair), Rosa Menendez, Stanislaw Blazewicz,(*vice* Rozploch), Francois Beguin, Malcolm Heggie. *In attendance*: Secretary, Chris Ewels, Bob Bradley, Xavier Bourrat and Elzbieta Frackowiak.

The European Carbon Association met to discuss and take decisions on four principal items.

(1) Web page - a problem has arisen with the former service provider for the ECA web page. The meeting unanimously accepted the British Carbon Group offer to host the web page themselves with Chris Ewels as Webmaster.

---

[*] S. Trasobares, C.P.Ewels, J. Birrell, O.Stephan, B.Q.Wei, J. A. Carlisle, D. Miller, P. Keblinski and P. M. Ajayan, *Advanced Materials*, 2004, **16**, 910

(2) Wolfgang Klose noted that there was a link between the carbon community and IUPAC (concerning terminology in carbons) in the form of Prof. Boehm who had been retired for some years now. It was felt desirable to renew this link and a set up a working group with a representative from each group chaired by the UK representative. (After the meeting Bob Bradley kindly volunteered for this role). In addition a web-based consultation process was suggested.

(3) Carbon 2006 - Bob Bradley gave an excellent presentation on the latest plans for Carbon 2006 which was well received.

(4) Carbon 2009 - Excellent presentations were given by Xavier Bourrat (on behalf of GFEC and the location in Biarritz) and Stanislaw Blazewicz (on behalf of the Polish Carbon Society). A lively discussion ensued, followed by withdrawal of the interested parties. While both bids had good features and it was felt that the Polish bid had much promise, it was decided to award C2009 to France. A suggestion that 2012 should be promised to Poland did not have the support of the majority of the committee. Each group then announced their plans for future meetings. Details should be available on the web page soon. It was also agreed that the Statutes of the ECA should be on the web page and possibly the Minutes could appear, but password-protected.

(5) A final item raised under AOB queried the period of tenure of the Chair (the appointment of the current Chair arose when the natural successor had to decline and some of the committee recalled that the tenure would only be for one year). Since the minutes were silent on the tenure of the Chair's appointment, the period of tenure was deemed to be the normal one, i.e. 3 years. Wolfgang Klose was thanked for his chairing of the committee and the meeting closed at 9pm.

And finally……

I've read with interest over the years the various papers from Spanish research groups concerning the use of olive stones for making active carbon. Presumably, there is an olive stone mountain in Spain that they are keen to shift. In fact, olive stones do make a very superior active carbon, combining high surface area with high piece density, which makes it a good candidate for use in Adsorbed Natural Gas (ANG) applications, amongst other things. I had however no idea whether or not the admirable research done on this material had had any commercial impact until recently.

The belated arrival of an English summer had led me to consider reactivating my barbecue. Having used up all my last year's stock of wood, I had to get some charcoal and in our local branch of Waitrose, my eye was caught by a green package that offered me "Briquettes de noyaux d'olives" which even my limited French could translate as "olive-stone briquettes". In addition, it promised me that it was "charbon protecteur des forêts" and what BCG member could resist a carbon protecting the forests? Not only that, it had a "combustion constante et intense" which is what one wants in a barbecue charcoal. Having thus exercised my skill in foreign languages, I pulled the packet out to find that there was an English translation on the other side, which was bit deflating. However, the translation differed in a few essential particulars from its French counterpart. For a start, it claimed to be made of olive stone *and* walnut shell and it promised to be easy to light, clean-burning (without the hyphen) and having low ash,

none of which claims appeared in the French version. Of these claims, the first was certainly justified but it was far from clean-burning and showed signs of not having been sufficiently activated, with smoke and flames billowing out for the first five minutes after ignition. Low ash? Well, I don't think so, as the carbon was made into briquette shapes and did leave quite a lot of residue which suggest that some forming agent was used in its constitution. Still, I have to say that when the flames died down it did give out a considerable and constant infrared radiation and cooked the barbecuate (if one might use this expression) to perfection.

However, there is still a mystery about the source of the carbon. One can get very good olive oil in the south of France but there would scarcely be a big enough production to warrant basing a charcoal industry on it. The packet gives no indication of the source other than to say that the product is sponsored by the World Wild Life Fund which I think is British in origin, although it does give a French web site address on the packet. I could I suppose have interrogated this about where they got their carbon but I was too idle to do so. Perhaps our Spanish and French colleagues can tell us whether we are indebted to their efforts to produce this alternative source of fuel.

Norman Parkyns