INVESTIGATION OF DIAMONDS AT SRS IN DARESBURY AND AT ROYAL HOLLOWAY COLLEGE

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As one of the early Polish synchrotron users, the author describes his synchrotron topographic experiments with diamonds at Daresbury during his employment as postdoctoral research assistant at London University from 1988 till 1991.

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My synchrotron activities started in October 1988, when I was employed as a postdoctoral research assistant at the Royal Holloway College, one of the colleges of London University. More exactly, in that period the name of the college was "Royal Holloway and Bedford New College" as it had been recently joined with Bedford College but later the college came back to the historic name.

Royal Holloway College is located close to the Great Windsor Garden in a nice campus between two small suburbs of London, Egham and Englefield Green. It was established on the base a former school for women founded by Thomas Holloway. He was a famous Victorian drug maker, a great philanthropist and an admirer of science and philosophy. The main building of the college, the so called Founders Building was designed by Sir William Crossland borrowing some concepts from the Chambord castle. It is, however, much smaller and furnished in red Victorian brick. The interesting thing was, that a part of the campus was considered as the possible location for the first British synchrotron.

I was the third Polish scientist participating in topographic investigations at Daresbury Laboratory after Marian Surowiec and Grzegorz Kowalski. At that time, synchrotron topography was very popular among Polish scientists and two other persons were making topographic experiments at HASYLAB in Hamburg.

My position was partly supported by De Beers diamond concern and the main subject of the investigations were synthetic and natural diamonds. The synchrotron investigation were an integral part of my activity, together with the conventional X-ray diffraction topographic experiments at the college. During my two years and nine month stay at RHBNC I took part in almost twenty five-days synchrotron experimental tours. The conventional X-ray investigations were very similar to my former activities at my Institute.

The important and very interesting novelty was the material – particularly large synthetic diamonds already attaining high crystallographic perfection. The large diamonds were obtained using the reconstitution method, which involves replacing the commonly used graphite carbon source with powder from small synthetic diamonds, preventing the change of carbon solution in longer processes of growing large diamonds.

Figure 1. A fragment of the Founders Building at the Royal Holloway College designed by Sir William Crossland.

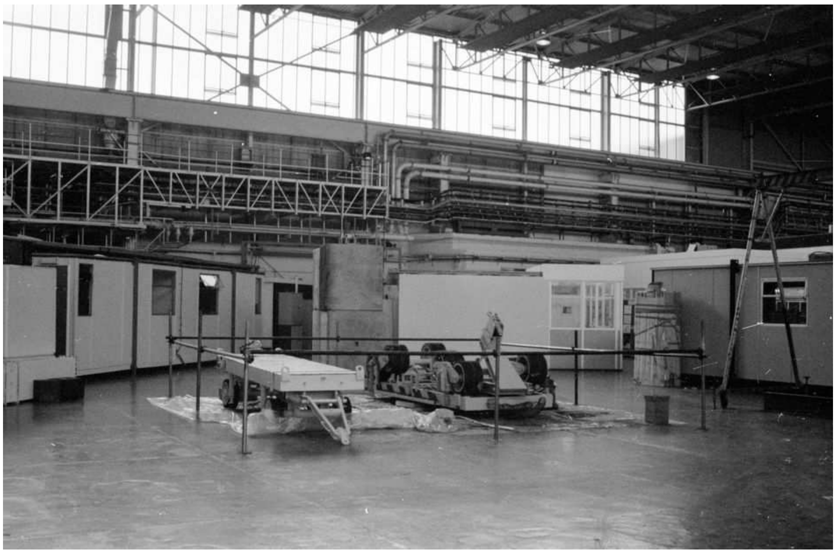

Figure 2. The view of the 7.6 "topographic" station in the SRS experimental hall at Daresbury Laboratory.

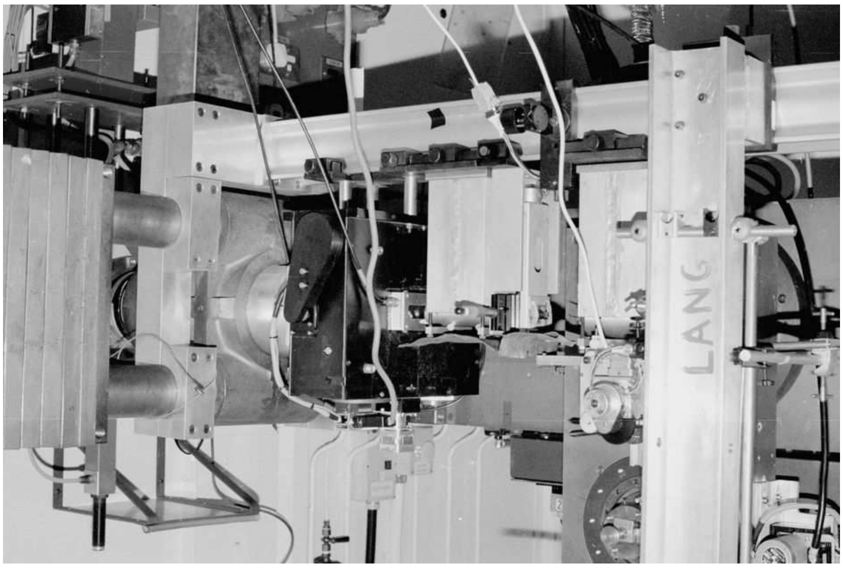

Figure 3. Our typical experimental setup constructed using a lot of additional mechanical items.

At that moment, almost twenty years ago, diamonds with the diameters greater than 1 cm were already grown, but the growth processes were long and expensive. These, being the subject of our studies (grown by De Beers and Sumitomo) were up to 5 mm in diameter. From the point of view of topographic experiments, a very pleasant feature of the diamond is its composition of very light atoms resulting in low attenuation of the second wave-field. Consequently, a large amount of various interference fringes is often present in the topographs.

My supervisor, Professor Moreton Moore was not only a brilliant scientist but also an activist to the local community. In the last few years he was elected as the Mayor of historical Runnymede county. Our team usually included also one or two PhD students, but a very important thing was a close cooperation with Professor Andrew Lang FRS from Bristol University, who was formally retired but is still scientifically active until today. Andrew Lang is acknowledged as the inventor of X-ray topography, as he first proposed a really matured and good working topographic method. He took part in more than a half of our Daresbury synchrotron experiments. It was for me a great pleasure to observe Andrew Lang at experimental work and learn his way of doing very good scientific work using relatively simple but very clever ideas.

The main topic of our investigation were the exact measurements of lattice parameters differences, between different growth sectors in large crystals of synthetic diamond, connected with different concentration of nitrogen. At that time the important problem in the synthetic diamond was the common presence of nitrogen impurity and its strong segregation in various growth sectors causing a considerable stress on growth sector boundaries.

The principle of our measurements of lattice parameter differences was not very complicated but the evaluations had to be performed very systematically. They were based on a huge number of topographs exposed in series passing a diffraction peak for different azimuths. The growth sectors were carefully identified not only on the base of crystallographic planes but also by observation of the cathodoluminescence features, providing very impressive colour patterns [1].

In the course of studying many synthetic and natural diamond we looked for various interference effects. My personal interest was mostly connected with the formed sample plate prepared from a cuboctahedral synthetic diamond grown by Sumitomo, by cutting off the areas of cubic vertex (one close to the seed) and other plates cut out from De Beers [2]. The interesting observation was some very intensive interference fringes in synchrotron transmission double crystal measurements, shown in Fig. 4,which finally we succeed to attribute to some growth sector boundaries. According to Andrew Lang's suggestion, to solve the problem we performed an experiment adopting the "Haruta pairs" technique to the case of transmission double crystal topographs – completing the pairs from a numerous series of double crystal topographs [3, 4] .

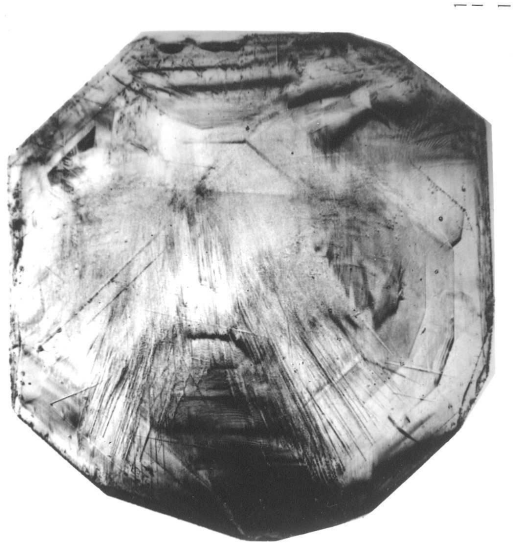

Figure 4. The interference fringes observed in the synchrotron transmission double-crystal crystal topograph of the Sumitomo synthetic diamond, taken in a $2\bar{2}0$ reflection of the 0.1 nm radiation. The fringes appear on dislocations, stacking faults and some growth sector boundaries [4].

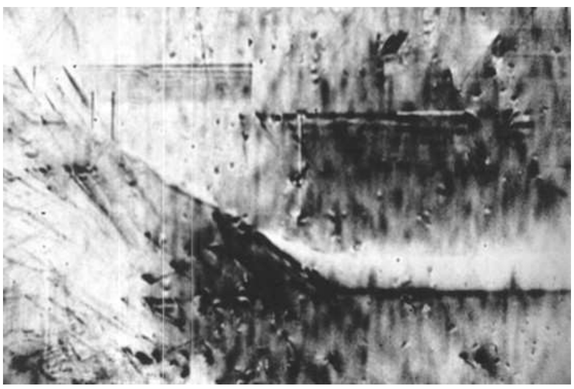

Figure 5. The back reflection (Bragg-case) synchrotron double-crystal topograph of (001) oriented diamond plate in 113 reflection of 0.154 nm radiation revealing interference fringes in images of the two stacking faults [7].

At some moment I was also able to propose some experiments of my own. In particular, I proposed an experiment involving observation of the transmitted beam images of also in Bragg case, which was fully published very recently [5]. The other experiment involved revealing the interference fringes in Bragg-Case double crystal topographic images of stacking faults, shown in Fig. 5, which were also explained theoretically on the basis of classical dynamical theory [6, 7]. Some interference effects were also observed using the section topography (spherical wave diffraction) in Bragg case both for dislocations [8] and stacking faults [9].

In case of natural diamonds the most important investigation concerned some new diffuse scattering effects observed with synchrotron double crystal arrangement on Ia type natural diamonds containing the so called "platelets", also caused by incorporation of nitrogen [10].

After finishing my period of employment in 1991 I had a three years break and I came back to synchrotron topographic experiments in 1994 at HASYLAB. But that is another story.

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