# Success Stories

## Design, Growth and Properties of Boron-based Thin Films for Electronics and Nanosized Electronics

The Science and Analysis of Materials Department (SAM) at the CRP Gabriel Lippmann is currently undertaking a three-year project within the scope of the INTER Programme entitled 'Design, Growth and Properties of Boron-based Thin Films for Electronics and Nanosized Electronics'. The project, headed by Henri-Noël Migeon and Nathalie Valle, is being run in collaboration with the University of Texas in Austin and aims to perfect the technique of growing, analysing, and studying the electric properties of nano-layers in boron carbonitride (BCN) ultra-thin films. The FNR funds the Luxembourg part of this collaborative project, while the U.S. National Science Foundation funds the U.S. part.

It is hard to comprehend the size of the thin films the project is studying. A nanometre is a 1,000th of a micrometer, which in turn is 1,000th of a millimetre, in other words there is a factor of one million between a millimetre and a nanometre (the same factor between a millimetre and a kilometre). The films, which the project is studying, are on average five nanometres (nano-layers) thick.

The BCN films have to be applied in the Integrated Circuit (IC) fabrication by the semi-conductor industry (although these films can be used by high precision toolmakers thanks to their good mechanical properties). The most advanced IC technologies use copper to connect millions of silicon-based components, but the copper can easily diffuse into other materials, especially to the porous adjacent films. So barrier films are required to minimise the IC damage by copper diffusion. BCN films are good candidates to replace the currently used SiCN barrier films, thanks not only to their low permittivity value but also to their better adhesion both with copper and with porous dielectric films.

The largest part of this research work at SAM concerns the characterisation of BCN films using a high performance technique called Secondary Ion Mass Spectrometry. This is a highly complex and specialised subject, due mainly to the small size of the films. In order to be able to determine the composition of the films they have to first perfect the technique of analysis. They are part-way through doing this by using a technique which they developed and patented in the laboratory (Caesium Deposition for Analytical Purposes), whereby they inject caesium onto the BCN surface in order to reach 100% ionisation efficiency, which then has to be quantitative. This technique works well with electronegative elements such as carbon and nitrogen.

One of the most challenging aspects at the start of the project was to find three PhD students with the competence to work in this field. As Migeon says, 'It is becoming more and more difficult to find top students specialising in this field, even for universities like Oxford. We sometimes have to abandon projects because we can't find the right people to work with'. Luckily for Migeon they were able to find the best people relatively quickly and they currently have two of the PhD students working in Texas and one at SAM in Luxembourg.

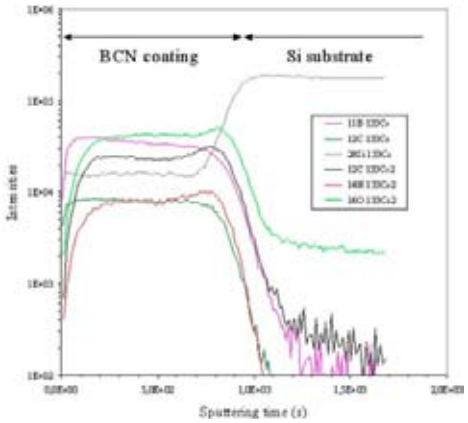


*Figure 1: In-depth analysis of BCN coating on silicon substrate.*

The synergy between the University of Texas and SAM is paramount to this project as they are both experts in different aspects; Texas has highly specialised equipment CVD (Chemical Vapour Deposition) from which they can prepare the material for analysis and SAM has cutting-edge technology and proficiency in the characterisation of surfaces. SAM is also in the process of perfecting a technique called PVD (Physical Vapour Deposition), which will allow the clinic to modify different compositions of the layers. At present it is very much in the preliminary stages and although they have managed to perfect the technique using thicker film (approximately 20 nm) they are still adapting the technique for the thinner 5nm film where it will remain stable enough to work with.

The quantitative measure of these layers (films) is not done to this scale elsewhere at the present time and although there is much research undertaken in the semi-conductor industry world-wide, using mainly silicon carbonitride (SiCN), SAM hopes to be the first laboratory to perfect the technique of using BCN film.

This is not the first SAM project which the FNR has supported (in fact they are also currently running a project under the TRASU and NANO programmes) but their contribution to the development of this new technology is unquestionable. Some of the equipment can only be found elsewhere in places like Harvard and Oxford University and NASA. This is invaluable to the development of nano-analysis in Luxembourg as without these highly-sophisticated tools advanced research could not be undertaken.

***CMS (cation mass spectrometer)**, a new powerful technique, designed by the SAM department, for quantitative characterisations.*