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NEWS

Annealsys - ONERA joint development program for h-BN / graphene hetero structures

Montpellier, France, November 16, 2020

Since 2018 Annealsys and ONERA are involved in a joint development program for the synthesis of boron nitride and of graphene - boron nitride hetero-structures by a vapor deposition technique assisted by infrared lamps (RTCVD). The joint development program's aim is the industrialization of the process for depositing thin films of boron nitride and hetero structures of graphene boron nitride on large substrates up to 100 mm in diameter. An Annealsys AS-One 100 HT RTCVD and RTALD reactor has been installed at ONERA for the process development.

The Graphene 2020, graphene and 2D material virtual conference was the opportunity to present the results of the recent development of a two-steps CVD synthesis of Boron Nitride Islands on polycrystalline nickel substrate. The results are available on the ePoster presented by Laure Tailpied (Ph.D. Student at LEM, the UMR ONERA-CNRS) and attached to this news release.

About ONERA:

ONERA is the French national laboratory for aeronautics and space R&T, staffed by 2000 people. Under the supervision of the French Ministry of Armed Forces, ONERA has an annual budget of 237 million euros, of which more than half comes from commercial contracts. As the French expert in aerospace technologies, ONERA prepares tomorrow's defenses, meets the aerospace challenges of the future, and contributes to the competitiveness of the European aerospace industry. ONERA masters all the disciplines and technologies in its aerospace fields. All major civil and military aerospace programs in France and Europe contain "DNA" from ONERA: Ariane, Airbus, Falcon, Rafale, missiles, helicopters, engines, radars, etc.

For more information visit ONERAs web site: https://www.onera.fr/

About Annealsys:

Founded in 2004 Annealsys and with more than 300 systems installed worldwide is a leading manufacturer of Rapid Thermal Processing and Direct Liquid Injection Deposition systems. We are supplying number of companies for the manufacturing of MEMS, sensors, optoelectronics, telecommunication, power and discrete devices. Many famous laboratories worldwide are using our machines for the development of future semiconductor, photovoltaic and nanotechnologies components. Our philosophy involves building up a long-term relationship with our customers, providing high reliability and high quality tools, insuring low cost of ownership and outstanding customer support.

For more information visit Annealsys web site: www.annealsys.com/

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Two-steps CVD synthesis of Boron Nitride Islands on polycrystalline nickel substrate

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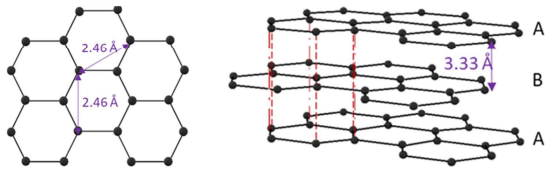
(1) DMAS/LEM, (2) DPHY/CMT (3) Annealsys

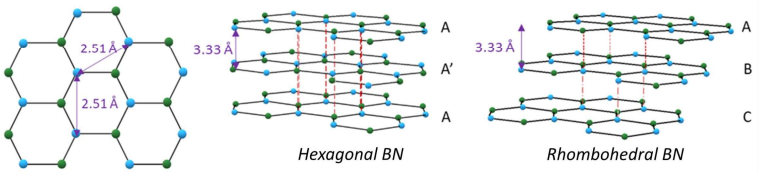
Graphene and sp²-hybridized boron nitride (BN) : unique and complementary 2D materials

Graphene



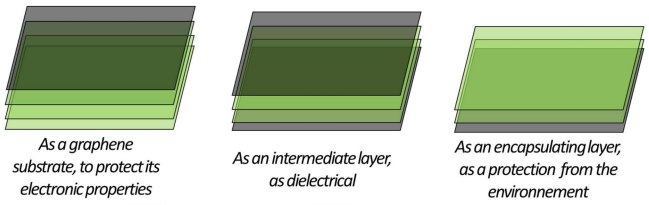
- ✓ Excellent conductor : $\mu_{Graphene}$= 200 000 $cm.V^{-1}.s^{-1}$ (102x $\mu_{Silicium}$)
- ✓ Record thermal conductivity : λ=5000 W/mK

sp²-hybridized BN



- ✓ High gap insulator (~6ev)
- ✓ Chemically and thermally stable

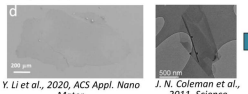
Role of BN in the Van der Waals heterostructures



Limitation: Few BN sources

Saint Gobain | HQ Graphene | NIMS, Japon | KSU, United-States | LMI, France

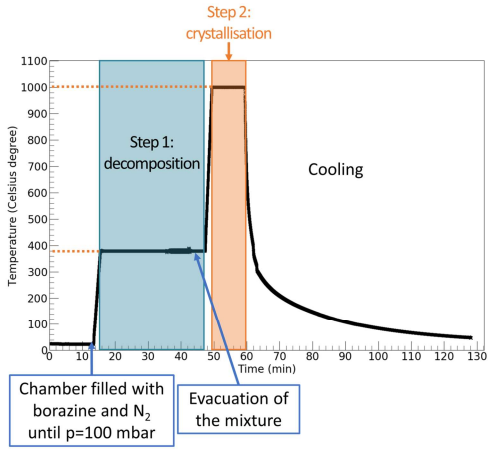
Mechanical or chemical exfoliation



- ✓ Good quality of the flakes
- × Limited size : <1 mm
- × Defects and inhomogeneity
- ➔ Need of a wafer scale synthesis

BN synthesis

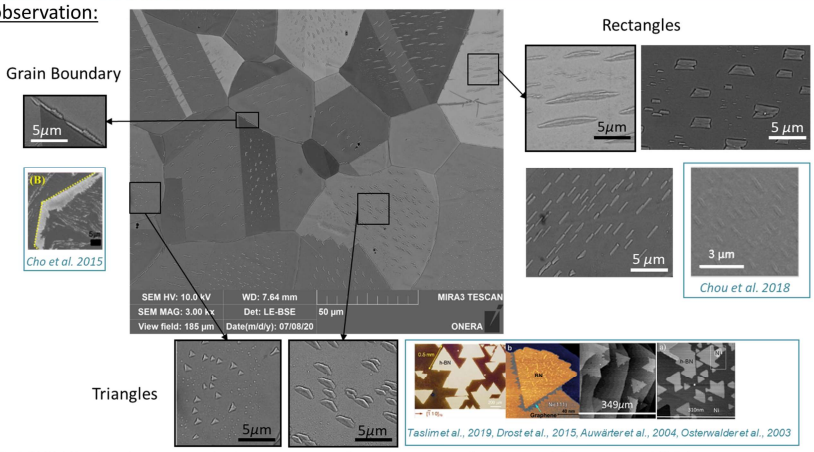
Set up: Low pressure chemical vapor deposition (LPCVD)-AS ONE Annealsys
Substrate : polycrystalline Ni, 99.99%, thickness=25 μm
Precursor : Borazine ($B_3N_3H_6$)
Process: Borazine reacts strongly under the halogens lamps used to heat the chamber ➔ two steps process used: Decomposition of the borazine at 380°C (Step 1) and crystalisation of the BN at 1000°C (Step 2) (*Y. Shi, 2010, Nanoletters*). The last step (step 3) is a fast cooling by extinction of the lamps under Ar/H_2.



Evolution of the temperature during a classical BN synthesis

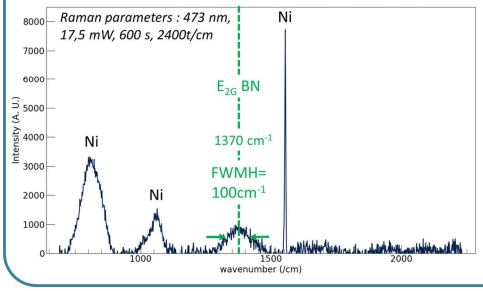
Results: BN islands

SEM observation:



BSE/SEM (NDLR : backscattered electron scanning electron microscopy) images exhibiting crystallographic contrast of the Ni susbtrate and related BN deposit

Raman spectra:



- ✓ Micrometer sized BN islands with shapes consistent with the data of the litterature
- ✓ Islands shapes different for each underlying Ni grain orientation *(H. Prévost, 2020, 2D materials)*
- ○ Very broad peak in Raman spectroscopy ➔ Low crystallinity ?

Conclusion & Perspectives

- ✓ BN islands are obtained from borazine with a two-steps process. Their size and shape change as a function of the orientation of the underlying Ni grain
- ❑ To obtain a better crystallinity of the BN, the duration of the crystallization step will be extended
- ❑ Other parameters, such as the temperature of the decomposition step and the cooling speed will be modified to obtain a BN continuous film

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