Scalable high-mobility graphene/hBN heterostructure

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02/09/2021

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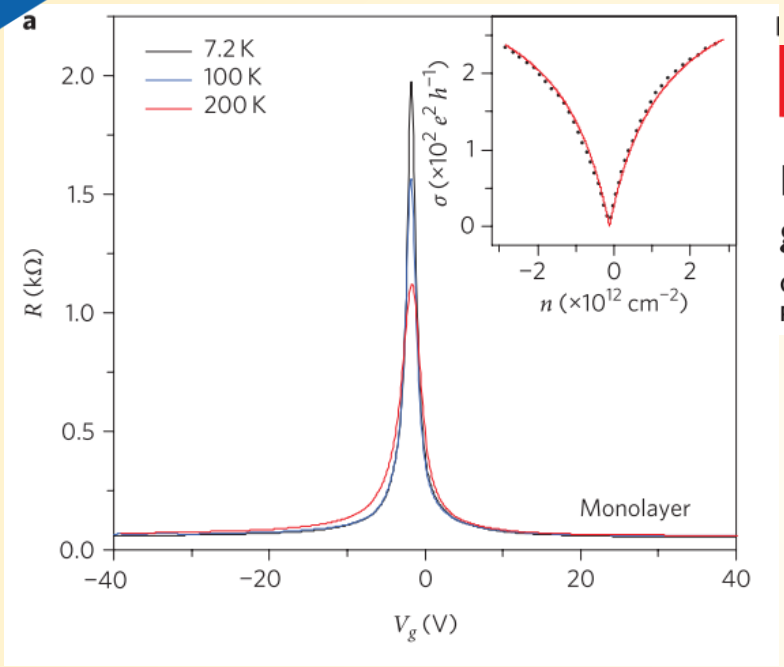
August 31 - September 03, 2021 • Bologna, Italy

European conference on chemistry of two-dimensional materials

Graphene encapsulation



LETTERS
PUBLISHED ONLINE: 22 AUGUST 2010 | DOI: 10.1038/NNANO.2010.172
nature nanotechnology

Boron nitride substrates for high-quality graphene electronics

C. R. Dean[1,2]*, A. F. Young[3], I. Meric[1], C. Lee[4,5], L. Wang[2], S. Sorgenfrei[1], K. Watanabe[6], T. Taniguchi[6], P. Kim[3], K. L. Shepard[1] and J. Hone[2]*

NANO LETTERS
Letter
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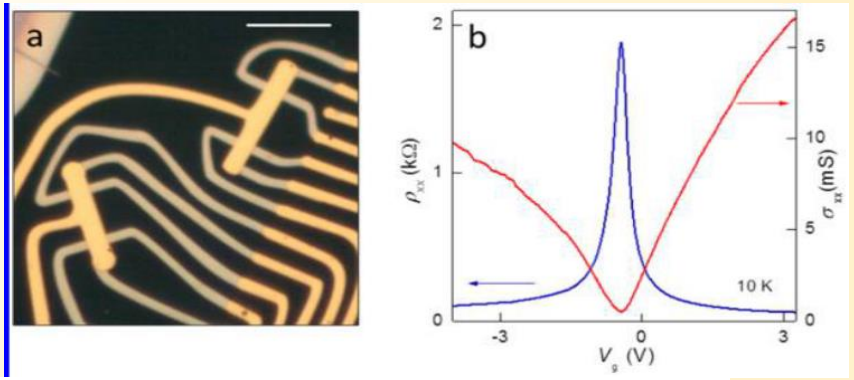
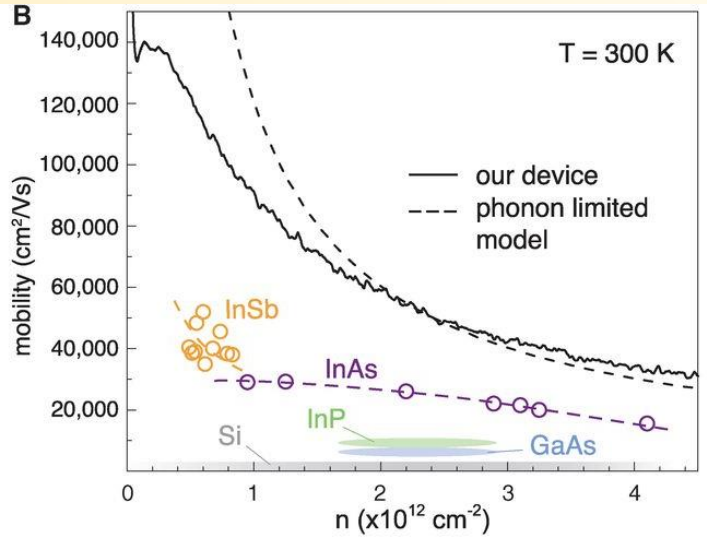
Electronic Properties of Graphene Encapsulated with Different Two-Dimensional Atomic Crystals

A. V. Kretinin,*[,†] Y. Cao,[†] J. S. Tu,[†] G. L. Yu,[‡] R. Jalil,[†] K. S. Novoselov,[‡] S. J. Haigh,[§] A. Gholinia,[§] A. Mishchenko,[‡] M. Lozada,[‡] T. Georgiou,[‡] C. R. Woods,[‡] F. Withers,[†] P. Blake,[†] G. Eda,[∥] A. Wirsig,[⊥] C. Hucho,[⊥] K. Watanabe,[#] T. Taniguchi,[#] A. K. Geim,[†,‡] and R. V. Gorbachev[†]





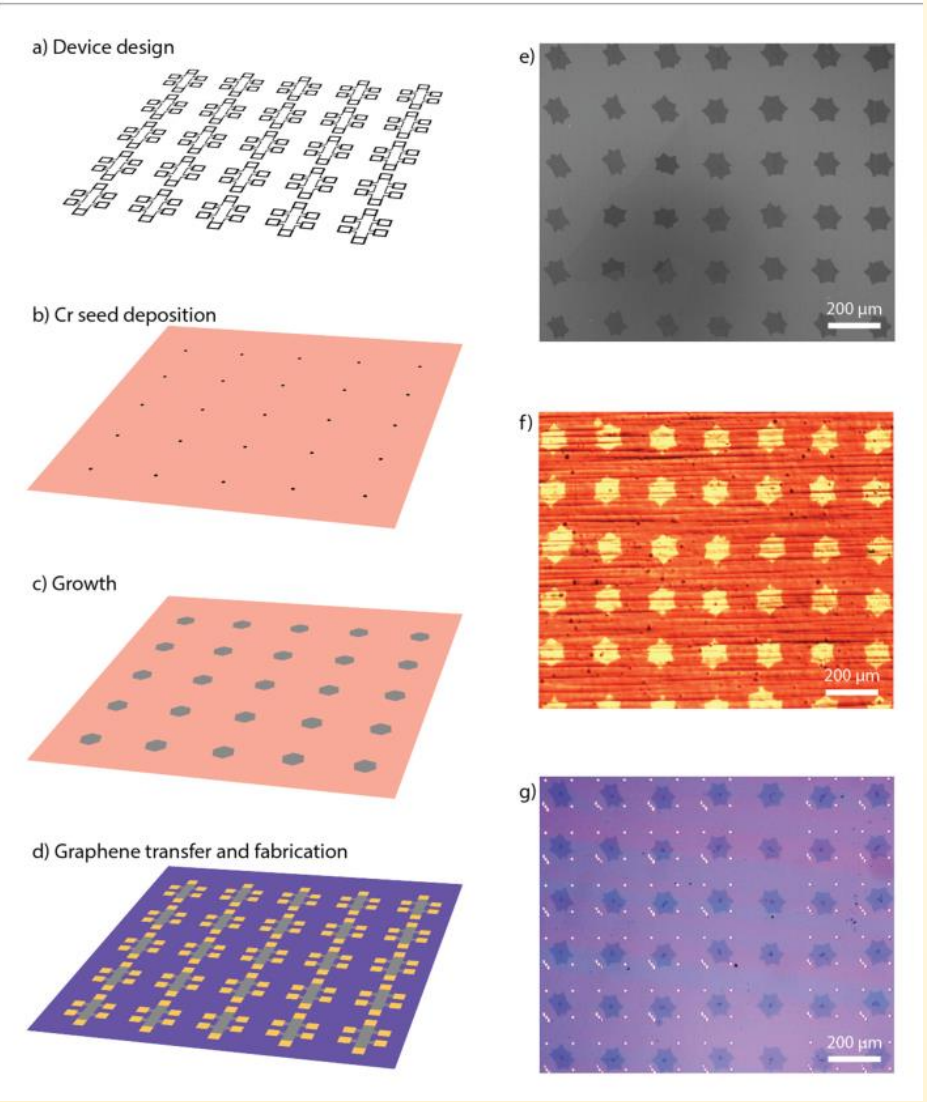
REPORT

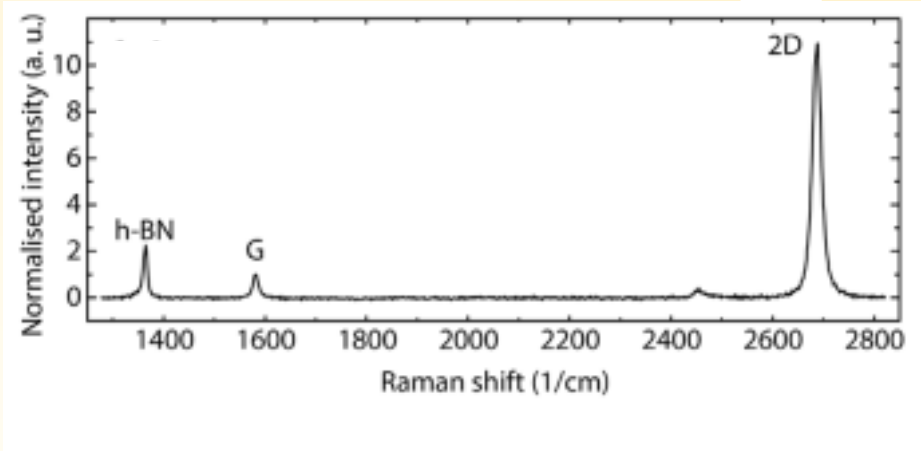
One-Dimensional Electrical Contact to a Two-Dimensional Material

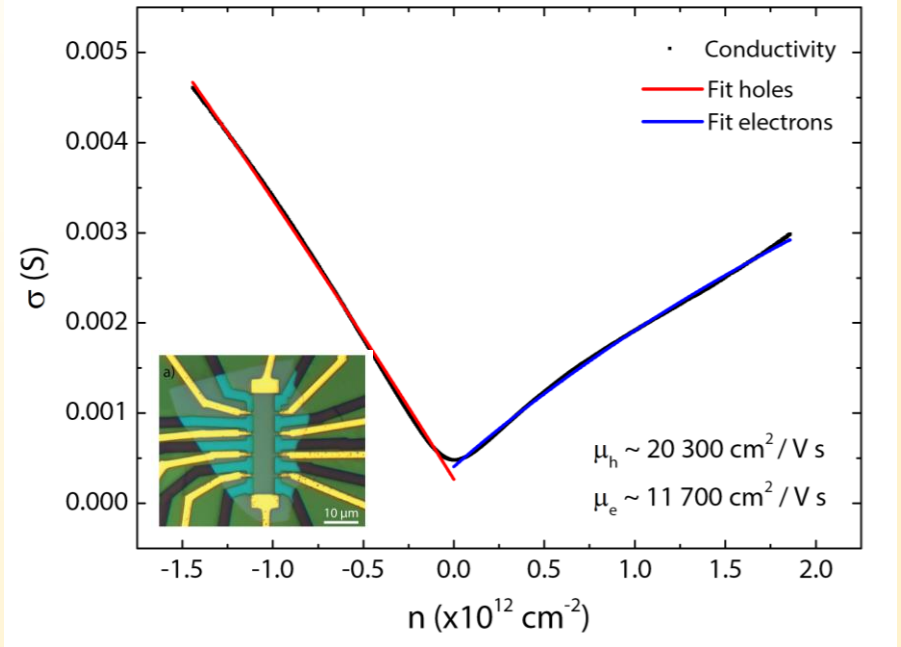
L. Wang[1,2,*], I. Meric[1,*], P. Y. Huang[3], Q. Gao[4], Y. Gao[2], H. Tran[5], T. Taniguchi[6], K. Watanabe[6], L. M. Campos[5], D. A. Muller...
+ See all authors and affiliations

Science 01 Nov 2013:
Vol. 342, Issue 6158, pp. 614-617
DOI: 10.1126/science.1244358

CVD-graphene







V. Miseikis et al., 2D Mater. 2 (2015) 014006

V. Miseikis et al., 2D Mater. 4 (2017) 021004

High quality CVD-graphene

2D Materials

LETTER

High-quality electrical transport using scalable CVD graphene

Sergio Pezzini[1,2,6], Vaidotas Mišeikis[1,2], Simona Pace[1,2], Francesco Rossella[3], Kenji Watanabe[4], Takashi Taniguchi[5] and Camilla Coletti[1,2]

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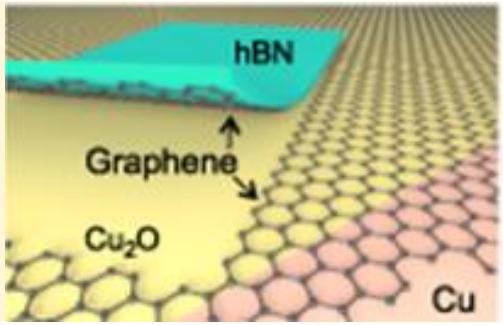
2D Materials, Volume 7, Number 4



2D Materials

LETTER • OPEN ACCESS

Fractional quantum Hall effect in CVD-grown graphene

M Schmitz[1,2], T Ouaj[1,2], Z Winter[1,2], K Rubi[3], K Watanabe[4], T Taniguchi[5], U Zeitler[3], B Beschoten[1] and C Stampfer[1,2]

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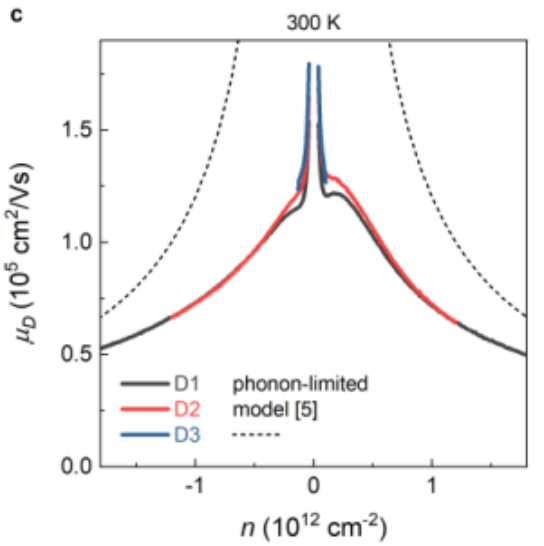

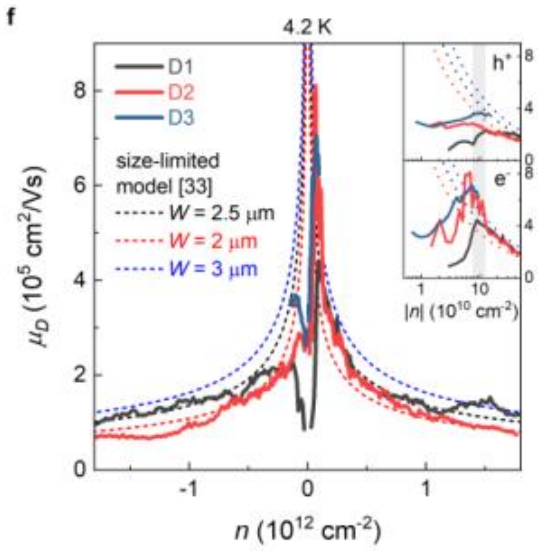

Scalable hBN sources

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nature COMMUNICATIONS

ARTICLE

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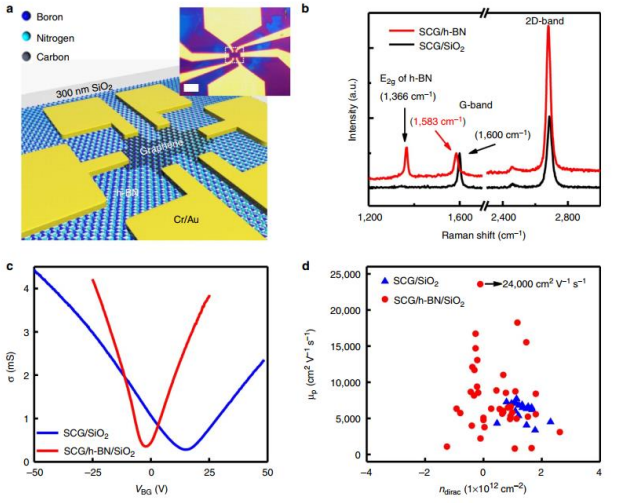
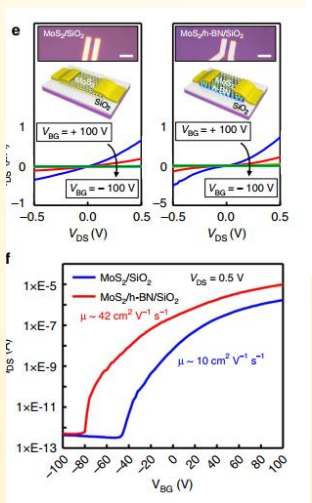
DOI: 10.1038/ncomms9662 OPEN

Synthesis of large-area multilayer hexagonal boron nitride for high material performance

Soo Min Kim[1,2], Allen Hsu[2], Min Ho Park[3], Sang Hoon Chae[4,5], Seok Joon Yun[4,5], Joo Song Lee[1], Dae-Hyun Cho[6], Wenjing Fang[2], Changgu Lee[7,8], Tomás Palacios[2], Mildred Dresselhaus[2,9], Ki Kang Kim[10], Young Hee Lee[4,5] & Jing Kong[2]





NANO LETTERS

Letter

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Wafer-Scale and Wrinkle-Free Epitaxial Growth of Single-Orientated Multilayer Hexagonal Boron Nitride on Sapphire

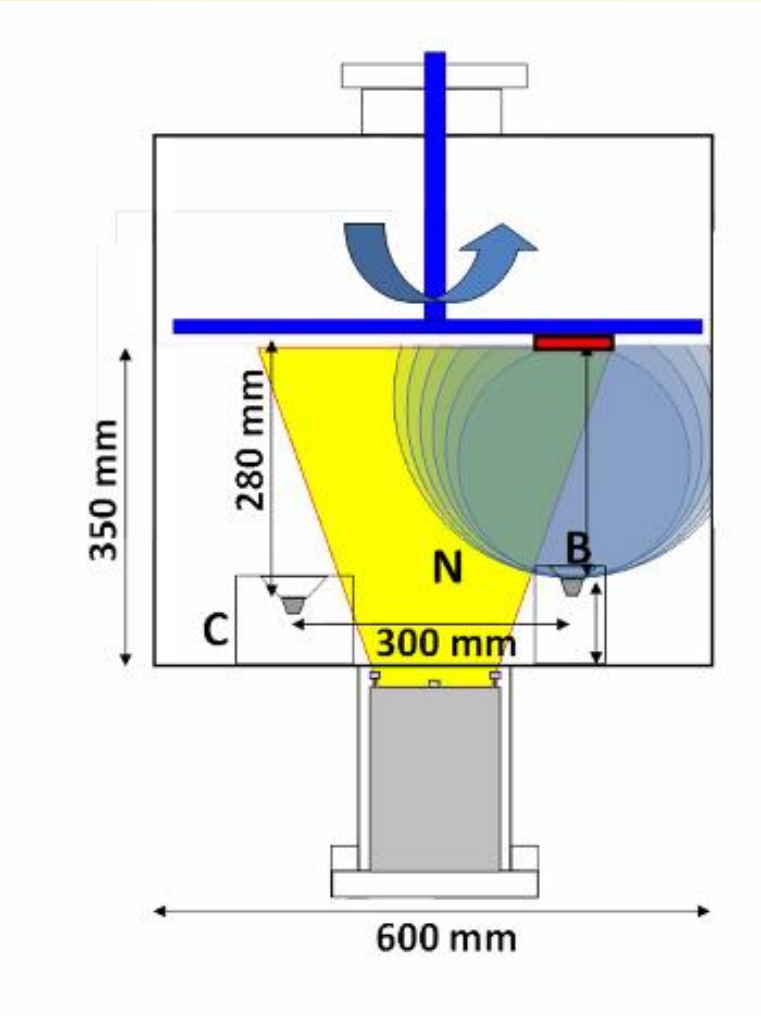
A-Rang Jang,[†,‡,§] Seokmo Hong,[†] Chohee Hyun,[‡] Seong In Yoon,[‡] Gwangwoo Kim,[‡] Hu Young Jeong,[⊥] Tae Joo Shin,[⊥] Sung O. Park,[▽] Kester Wong,[▽] Sang Kyu Kwak,[∥,▽] Noejung Park,[∥,#] Kwangnam Yu,[○] Eunjip Choi,[○] Artem Mishchenko,[◆] Freddie Withers,[◆] Kostya S. Novoselov,[◆] Hyunseob Lim,[*,†,‡,§,∥] and Hyeon Suk Shin[*,†,‡,§,∥]

Synthesis and Characterization of Hexagonal Boron Nitride Film as a Dielectric Layer for Graphene Devices

Ki Kang Kim,[†,‡] Allen Hsu,[†] Xiaoting Jia,[§] Soo Min Kim,[†] Yumeng Shi,[†] Mildred Dresselhaus,[†,⊥] Tomas Palacios,[†] and Jing Kong[†,*]

It is possible to improve the graphene electrical characteristics, using scalable hBN, but we are still not in pair with exfoliated hBN

PVD - IBAD hBN growth



- hBN thickness between 10 and 20 nm
- Either hBN with basal plane orientation perpendicular and parallel to the substrate have been studied
- Sample growth with Boron and B_4C as solid precursor has been tested
- Graphene has been successfully transferred on hBN growth from Boron and B_4C precursors, and planar orientation either parallel and orthogonal to the substrate

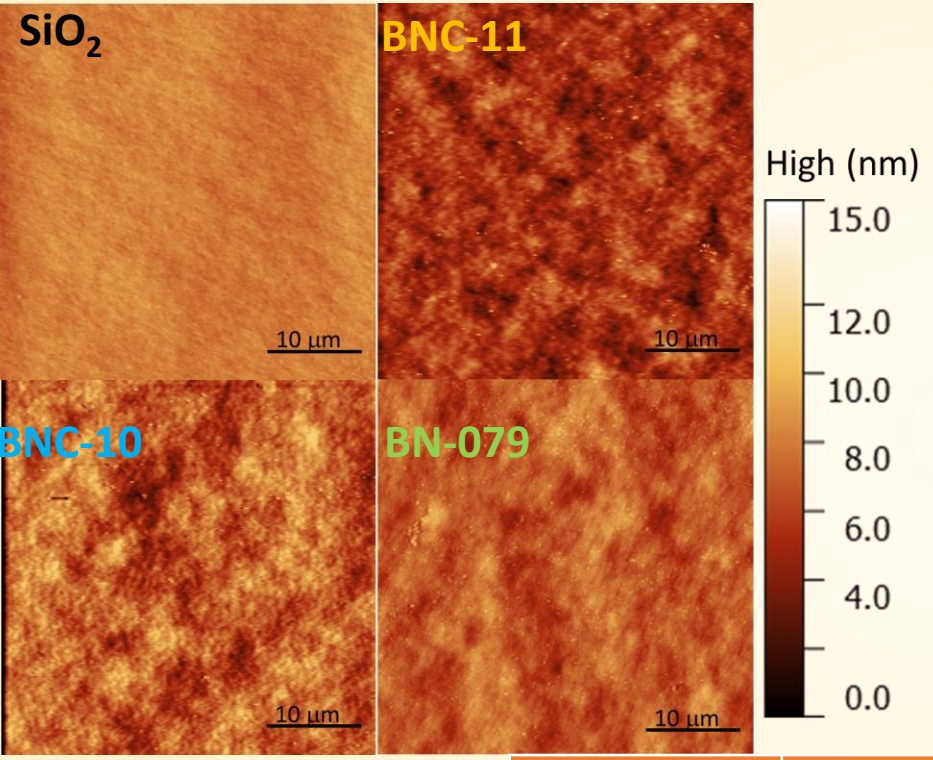
Claudia Backes *et al* 2020 *2D Mater.* **7** 022001

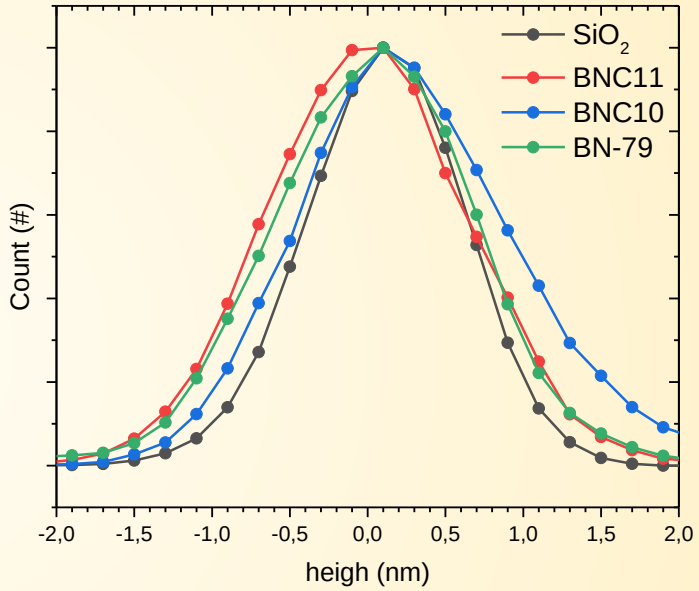
R. To – IBAD growth of hBN rres *et al*, Carbon 74 (2014) 374 – 378

I. Jimenez *et al*, . Mater. Res., Vol. 27, No. 5, Mar 14, 2012

I. Caretti and I. Jimenez, J. Appl. Phys. 110, 023511 (2011)

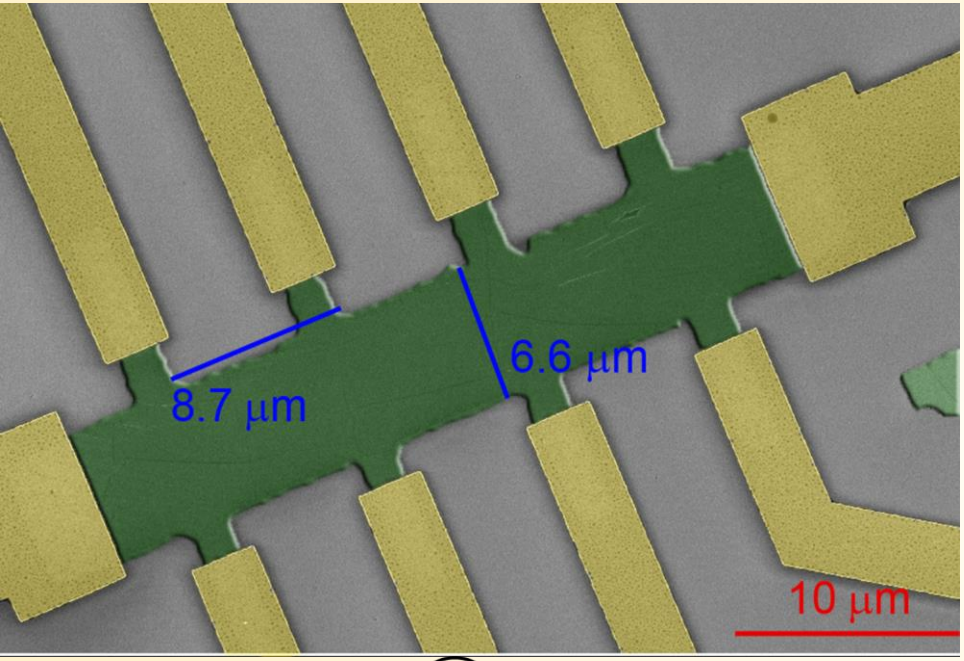
hBN roughness - AFM

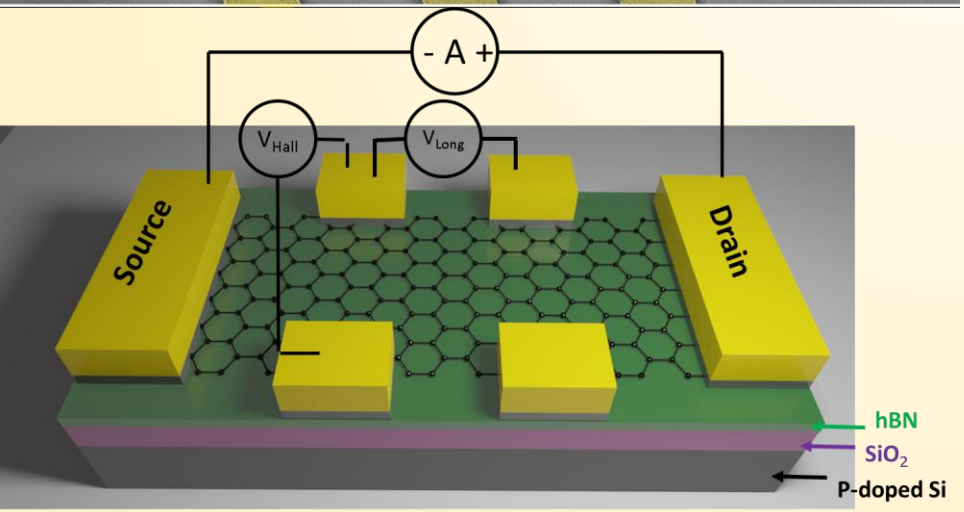


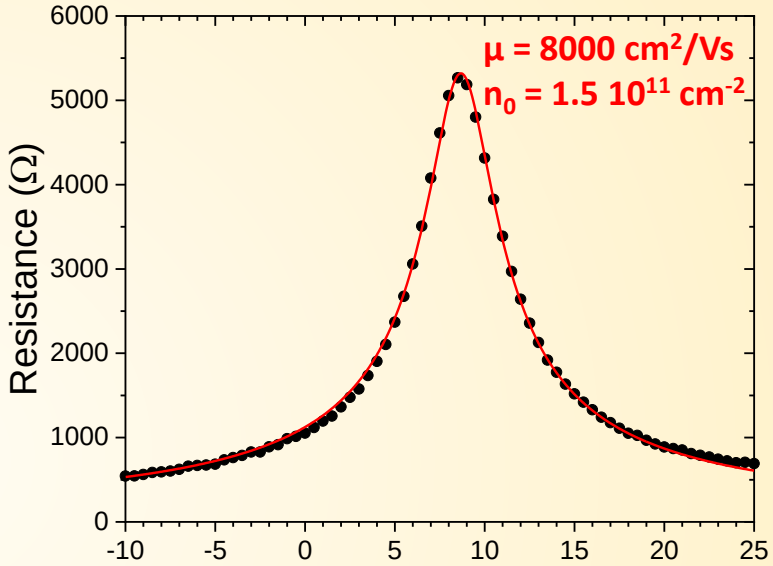


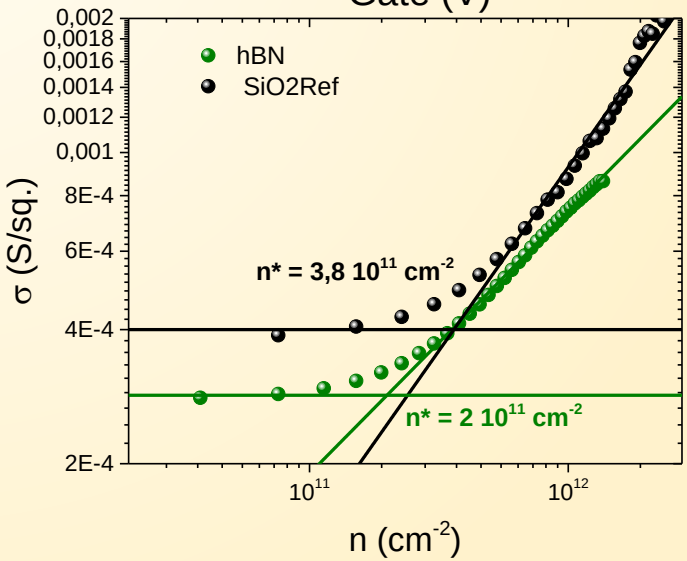
Sample name	Substrate	Precursors	Thickness (nm)	Orientation
DE-BN-79	SiO_2(300nm)/Si	B(vap) + N_2^+	10	Parallel
JA-BCN-011	SiO_2(300nm)/Si	B_4C(vap) + N_2^+	20	Perpendicular
JA-BCN-010	SiO_2(300nm)/Si	B_4C(vap) + N_2^+	10	Parallel

Graphene transfer on hBN: device fabrication

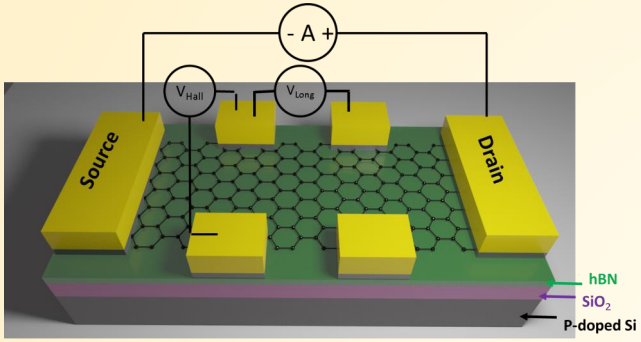


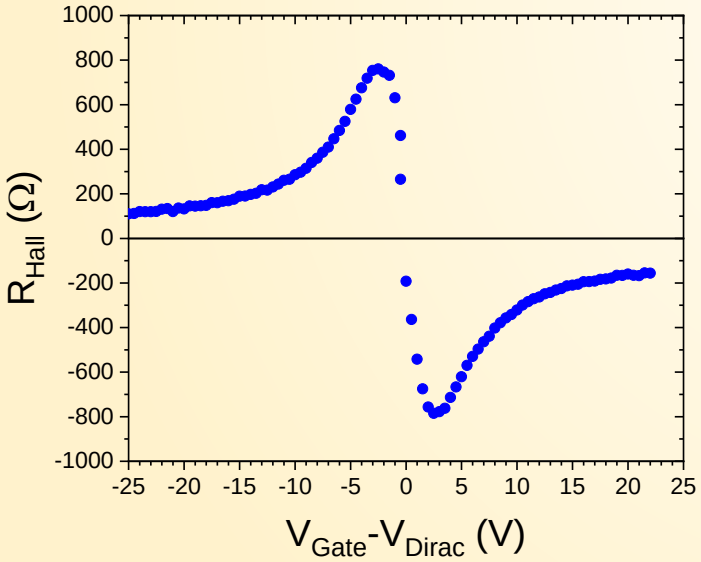


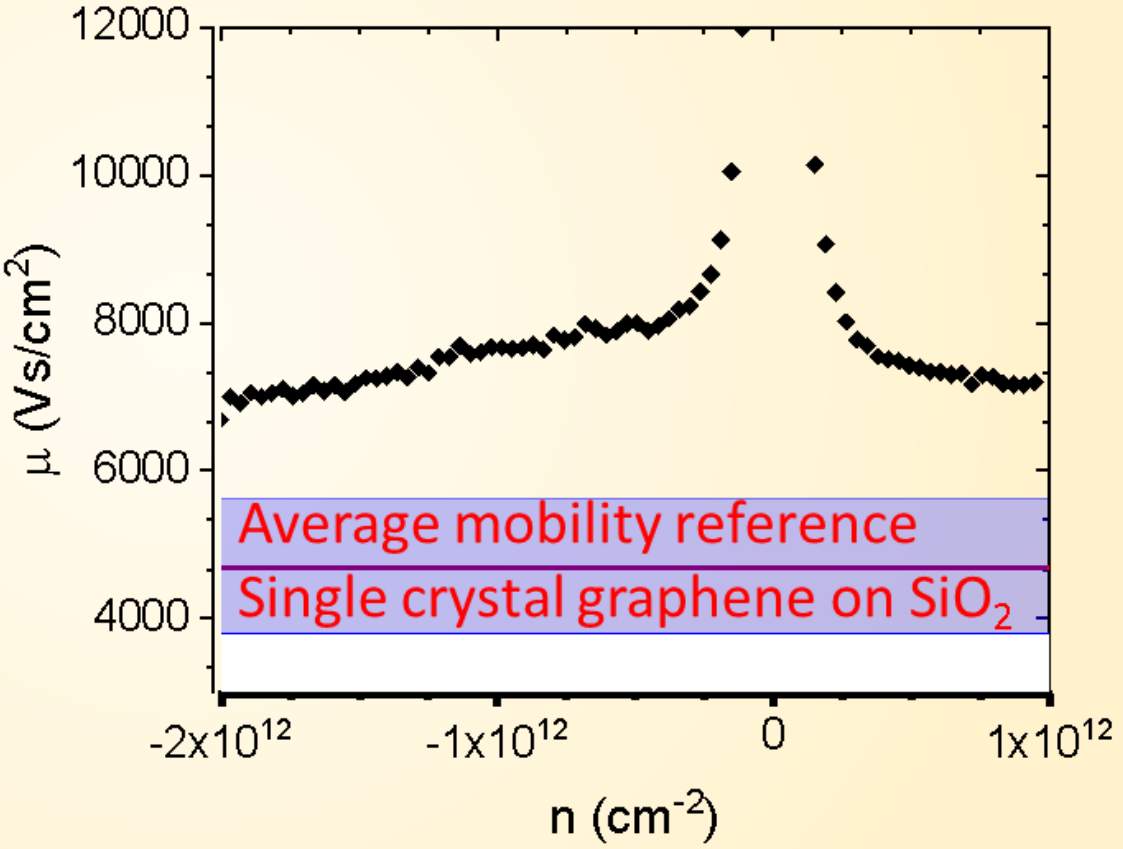




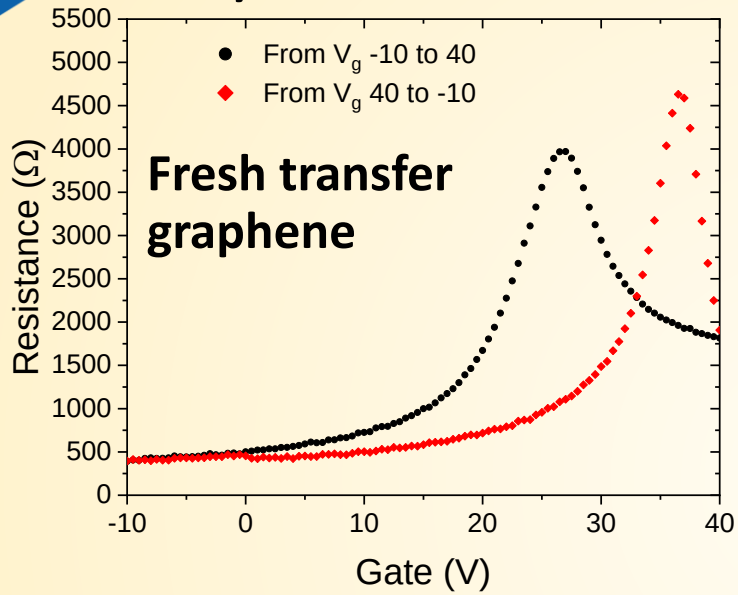
Graphene on hBN: electrical characterization

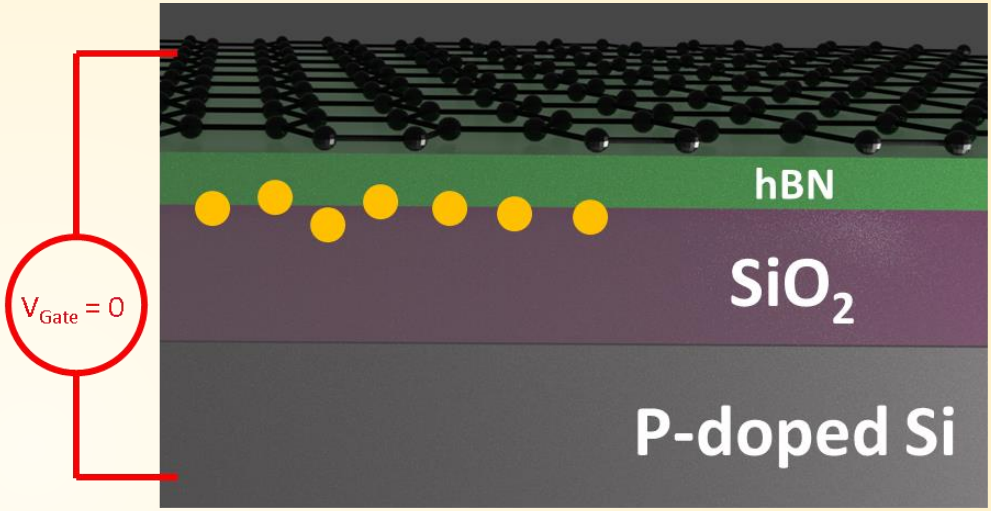


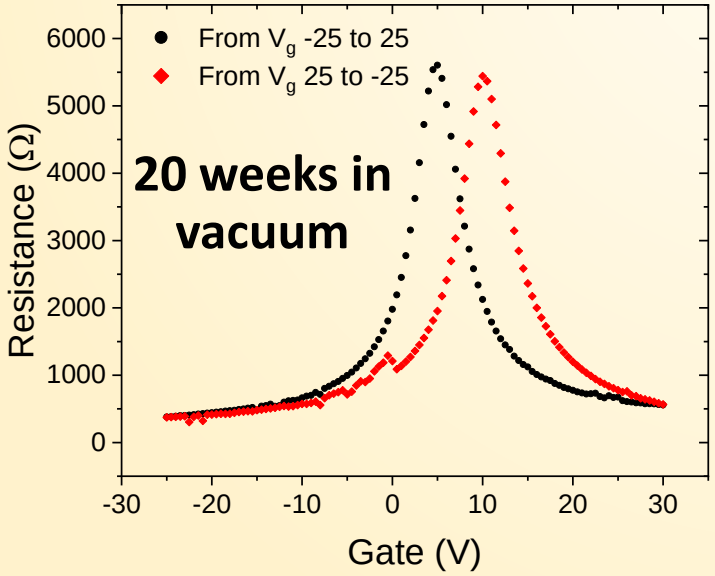


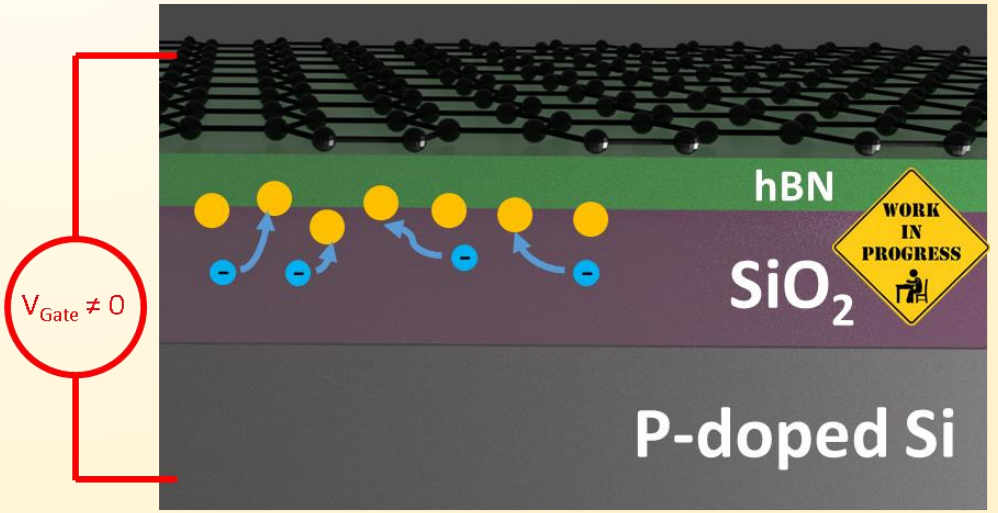


Graphene on hBN: hysteresis in the transfer curve









Exfoliated hBN as dielectric for g-FET

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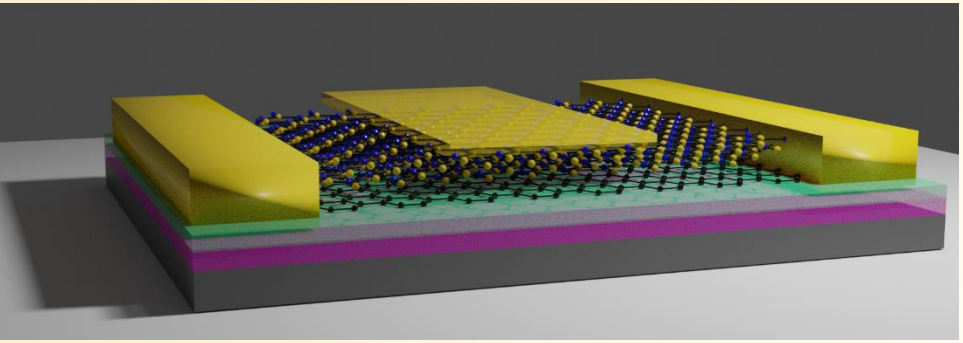
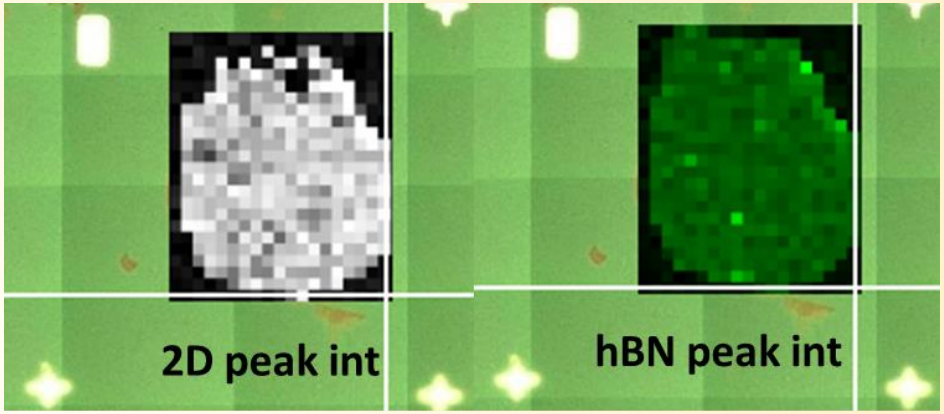
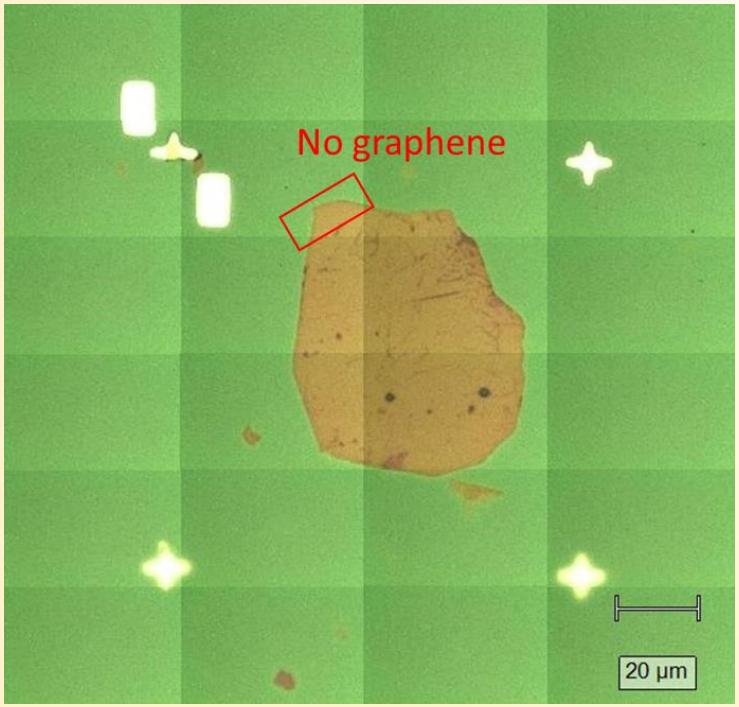
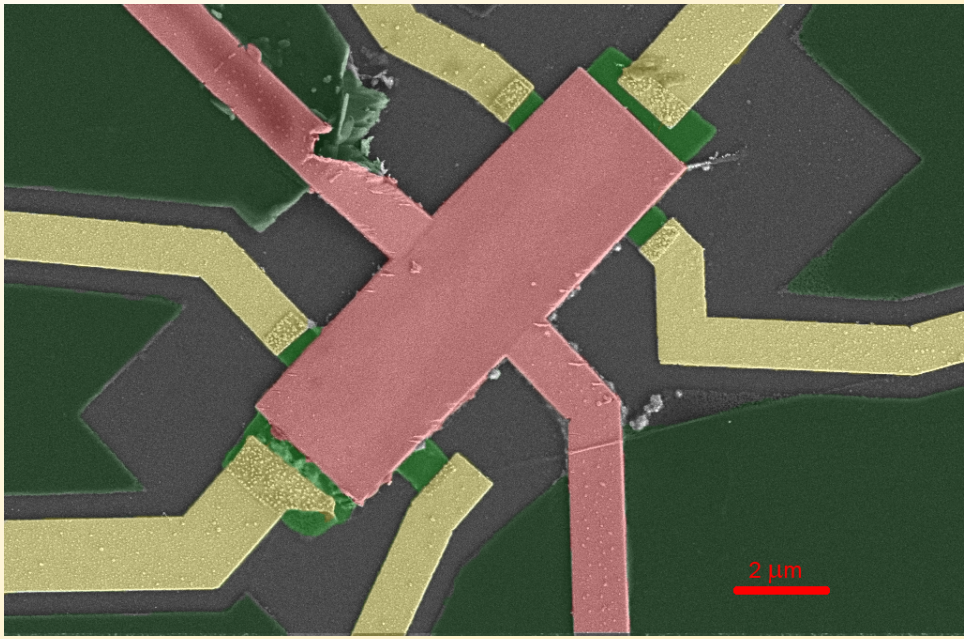
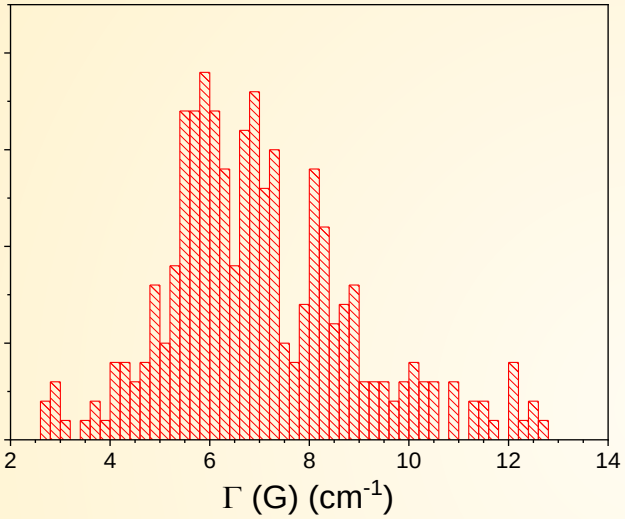


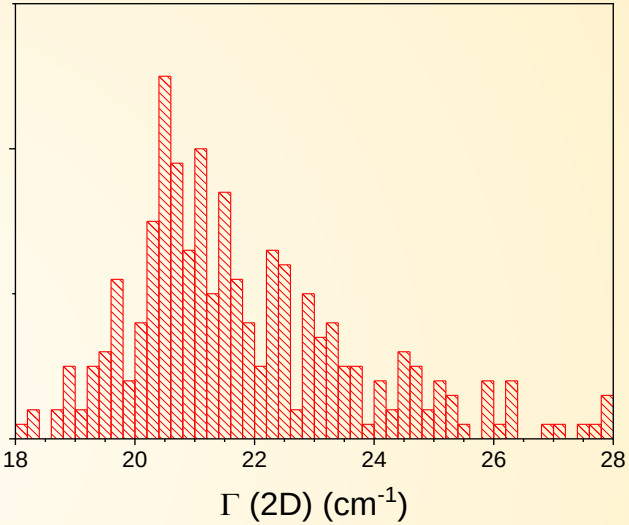


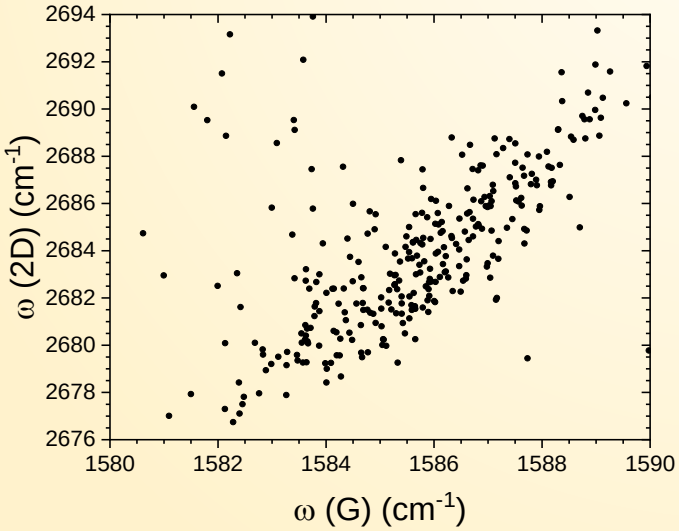


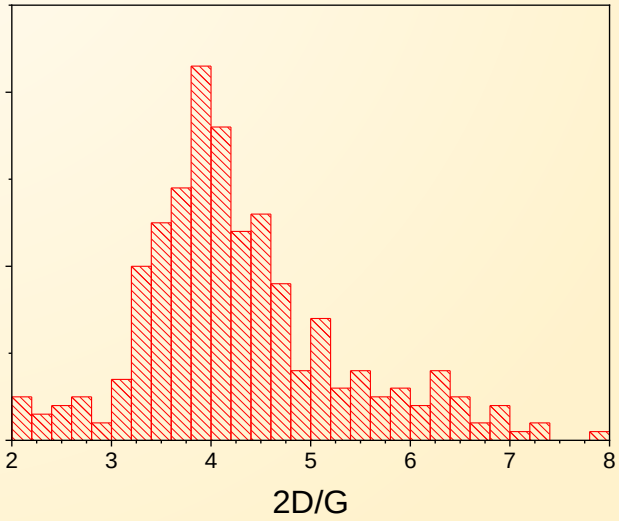


Exfoliated hBN as dielectric for g-FET

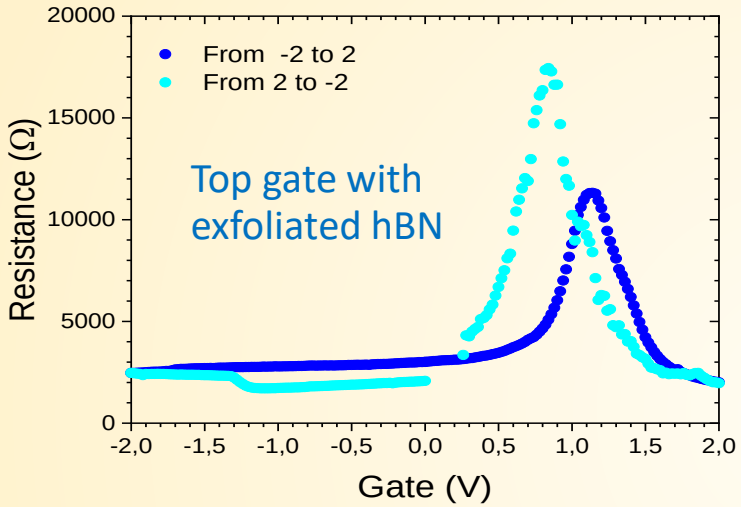


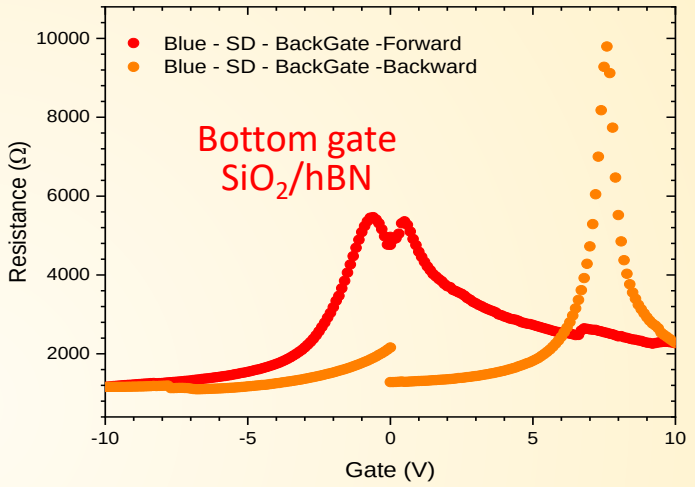


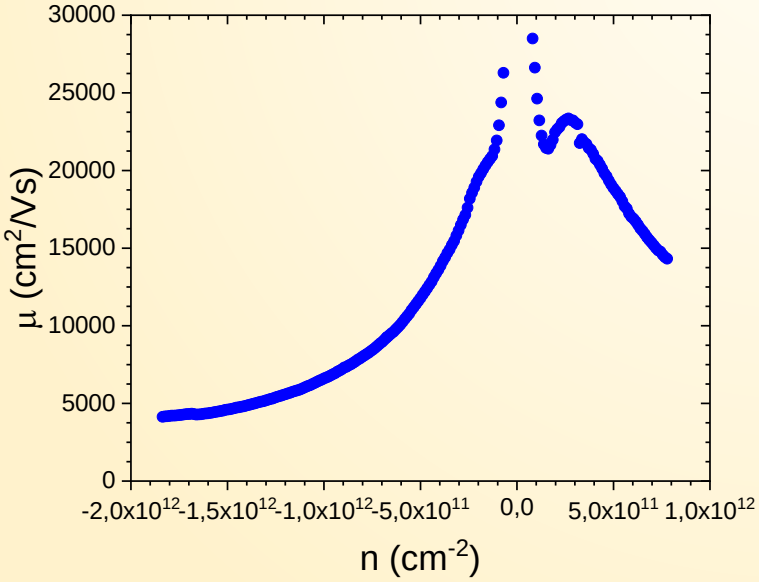


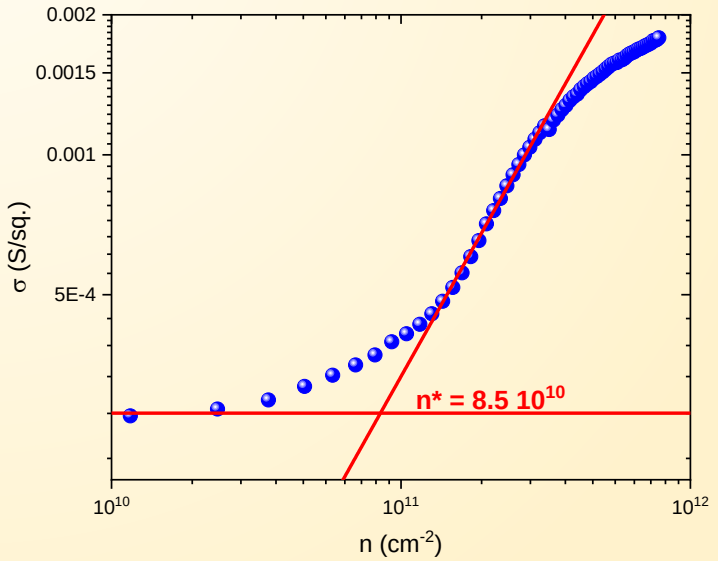


Exfoliated hBN as dielectric for g-FET









Conclusion and further perspective

- IBAD grown hBN presents roughness in pair with the growth substrate
- High quality scalable single crystal graphene has been successfully transferred on scalable hBN
- The scalable graphene/hBN stack has been characterized via AFM, Raman spectroscopy and electrically
- Doping of graphene on hBN is comparable with that measured on SiO_2/Si substrates
- Raman indicate strain reduction for graphene on hBN
- RT mobility of grapheme/hBN is ~10 000 cm^2/Vs, a factor 1.5 higher than those measured on SiO_2/Si substrate
- RT mobility of **15 000 cm^2/Vs** has been measured implementing an exfoliated hBN top gate.

- Further reduction of the roughness could be achieved with a transfer of the hBN film on a pristine substrate
- Characterization of the hBN as dielectric is still under development
- Full-scalable graphene encapsulation, with IBAD-grown hBN

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