Microwave plasma enhanced chemical vapor deposition synthesis and applications of few layer graphene.

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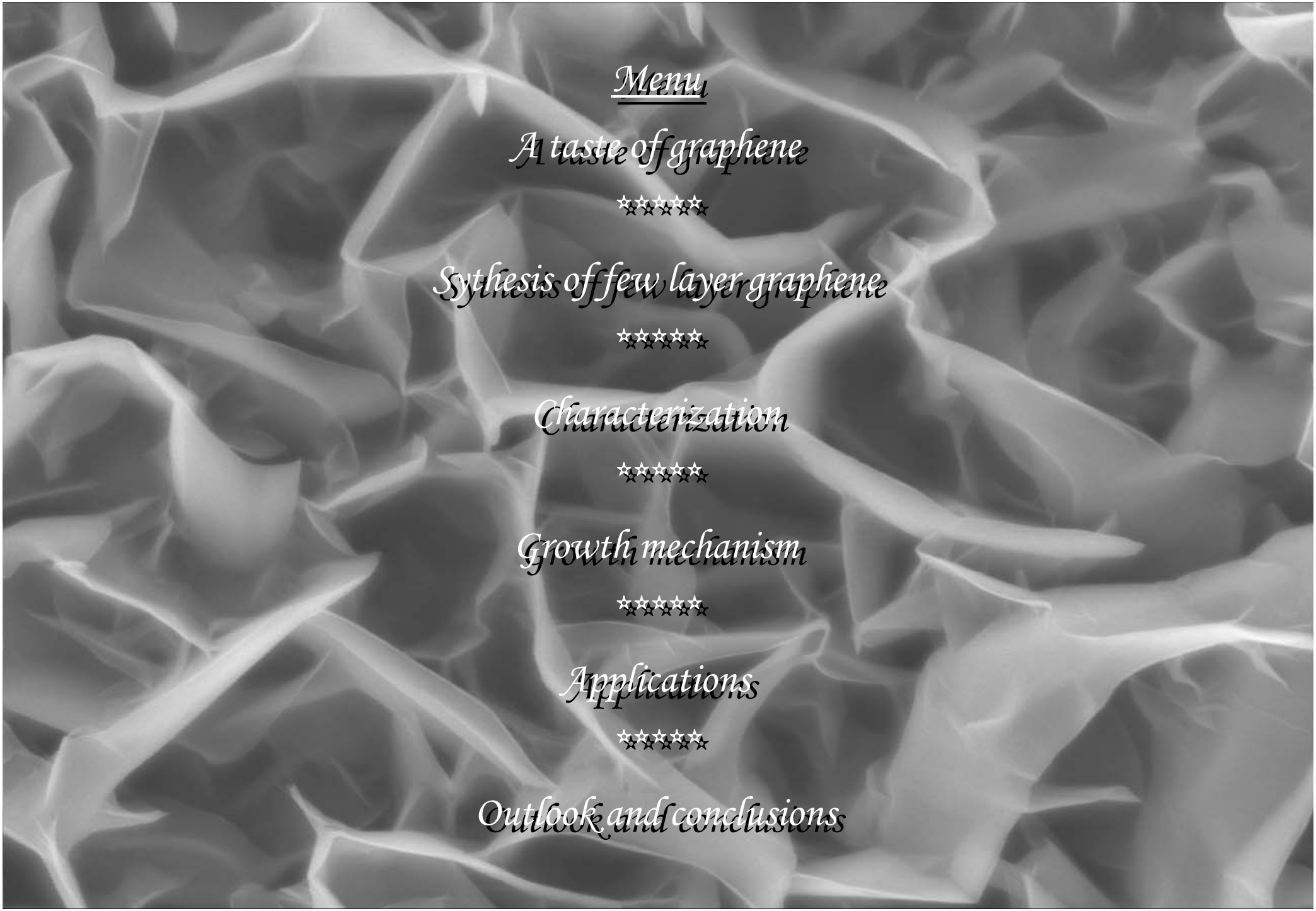
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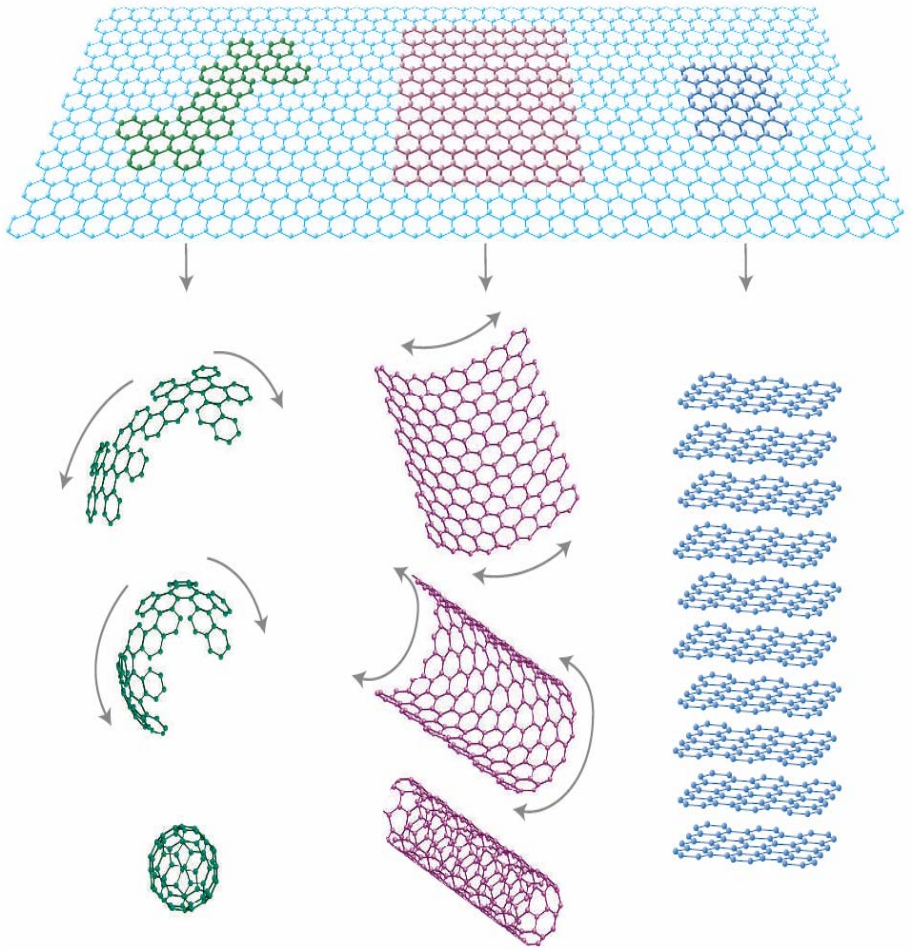
A taste of graphene
Sythesis of few layer graphene
Characterization
Growth mechanism
Applications
Outlook and conclusions

Introduction

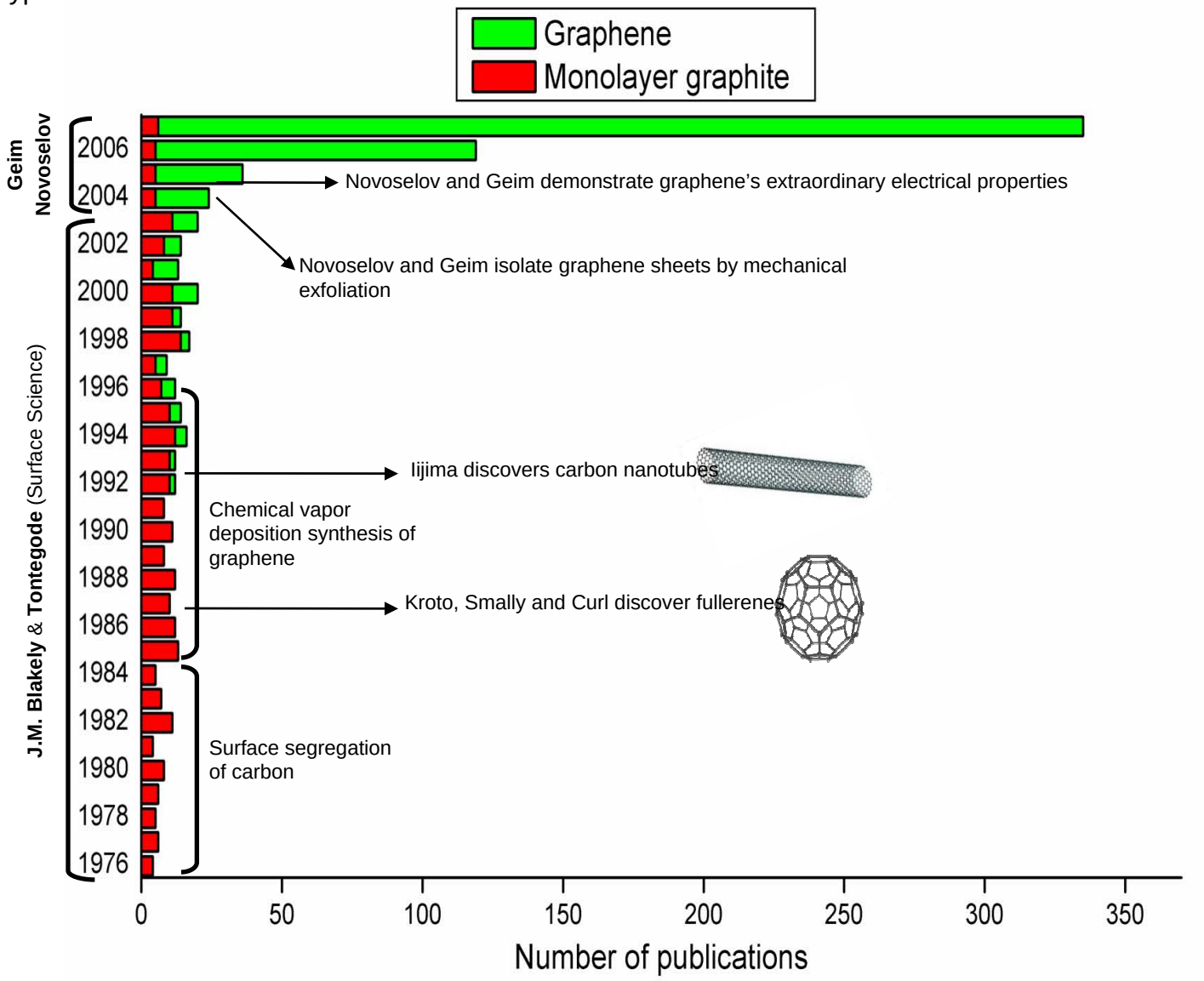
Graphene, the mother of all graphitic allotropes



A.K. Geim and K.S. Novoselov, The Rise of Graphene, Nature Materials, 6, 183, 2007

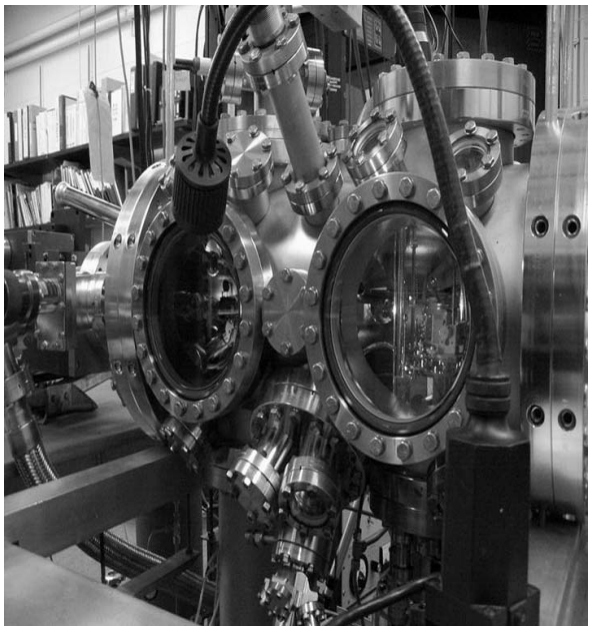
Introduction

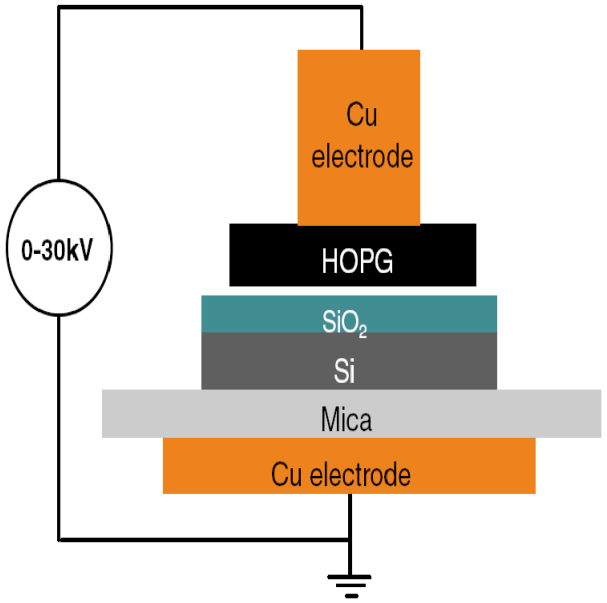
History of a hype

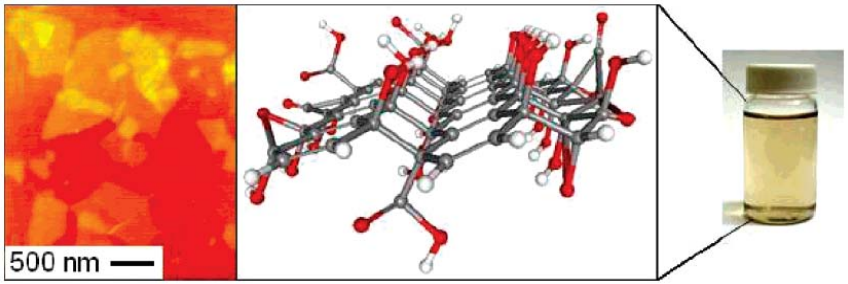


Introduction

Graphene synthesis techniques







Proc. Natl. Acad. Sci USA, 102, 10451, 2005

Solid State Communications 143, 92-100, 2007

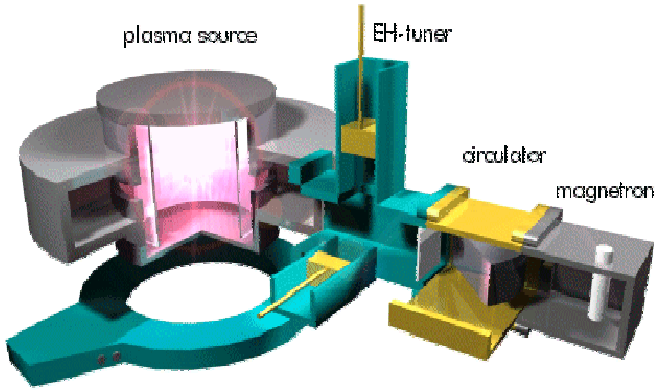
Nanotechnology 18, 135301, 2007

Nano Letters, 7 (11), 3394, 2007

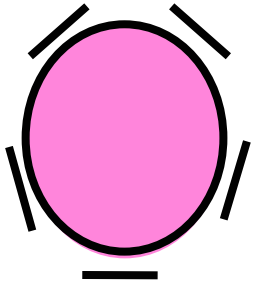
Experimental Setup

Iplas Cyrannus microwave plasma source

Side view



Top view

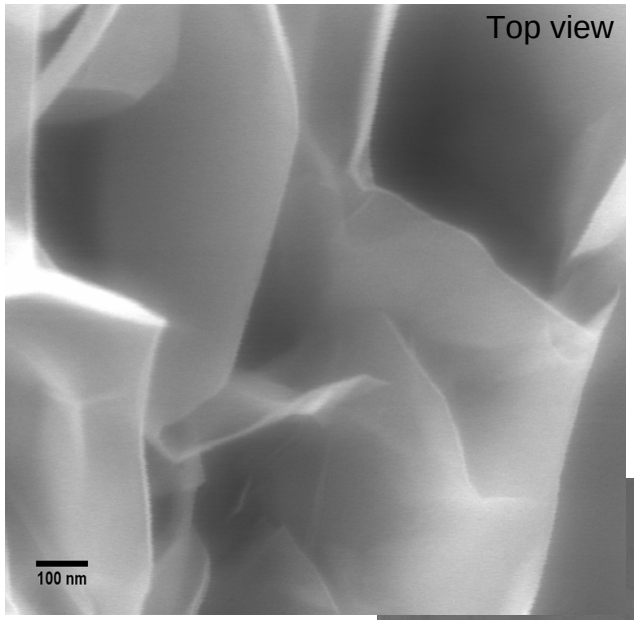


TM 012 mode

$n_e \sim 10^{13}$ / cm²

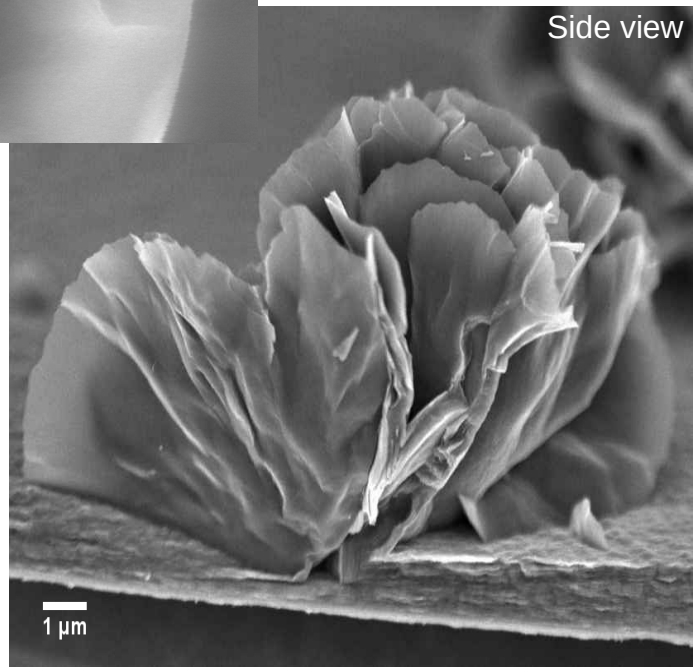
Few layer graphene synthesis

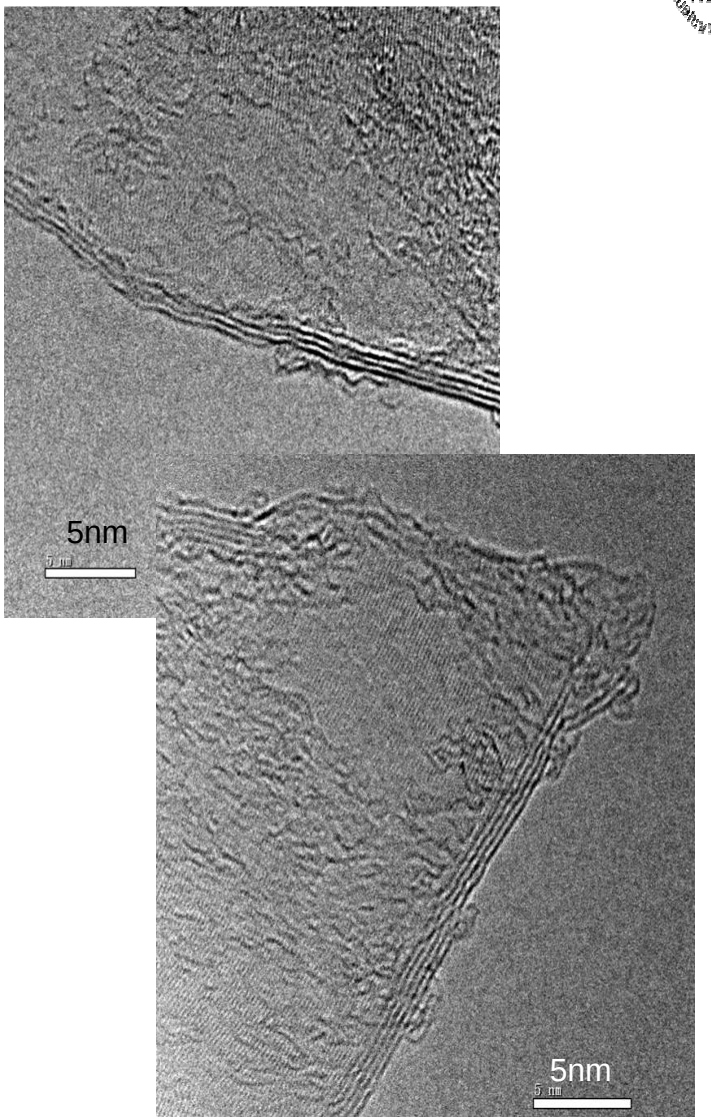
Scanning (left) and transmission (right) electron microscopy



Conditions:

Plasma mode:	TM012 mode
Samples:	Si/SiO_2, Mo, Pt, Ti,...
Microwave power:	2000 W
Pressure:	40 Torr
Temperature:	+/- 1000°C
Bias:	0 V
Gas:	CH_4 / H_2 = 1 / 8 total gas flow 200 sccm

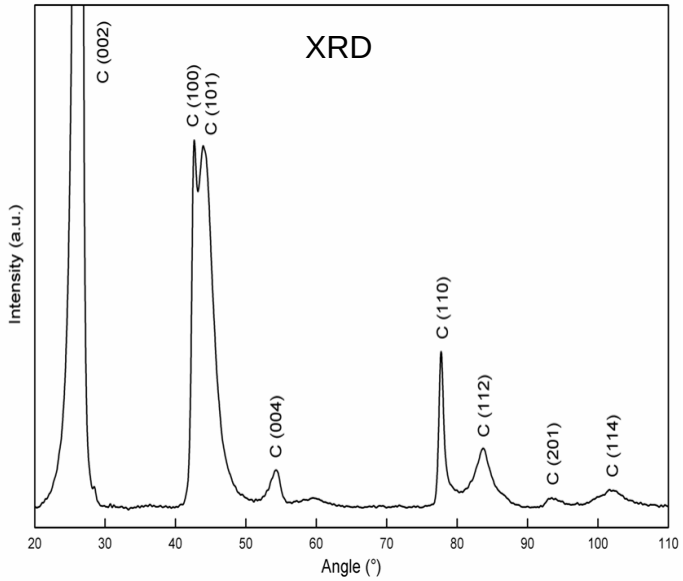


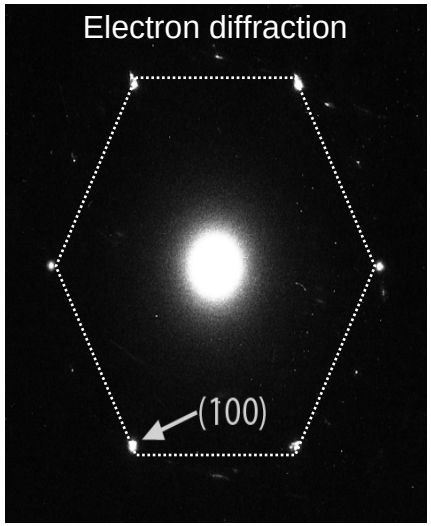


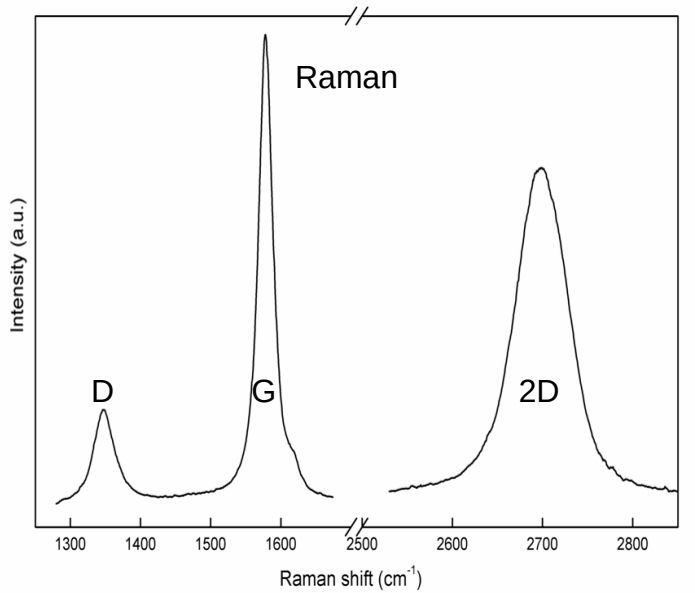
A. Malesevic et al., Nanotechnology, in press 2008

Few layer graphene synthesis

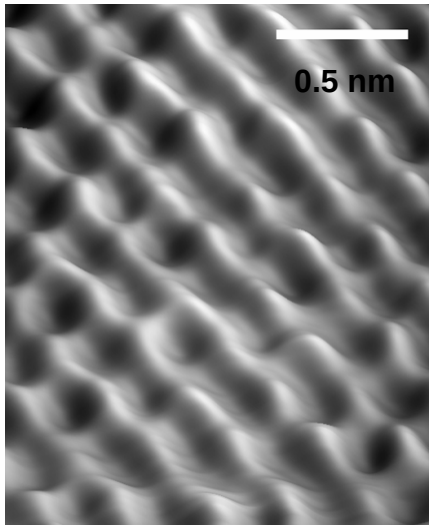
Qualitative analysis







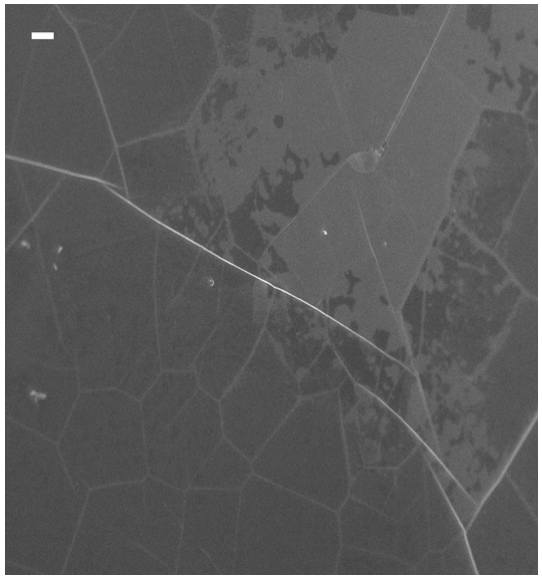
Low temperature STM

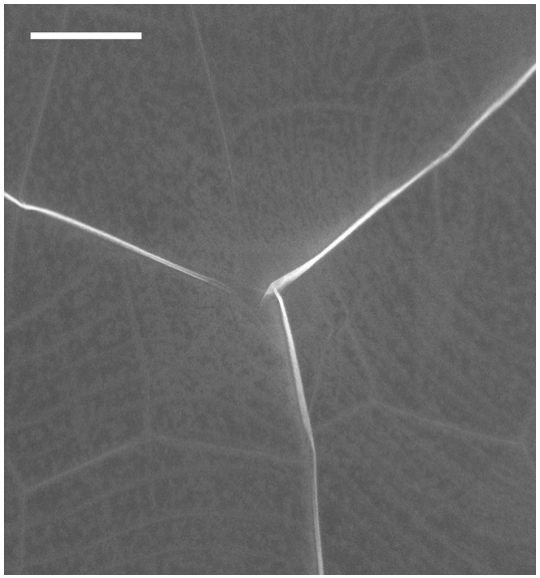


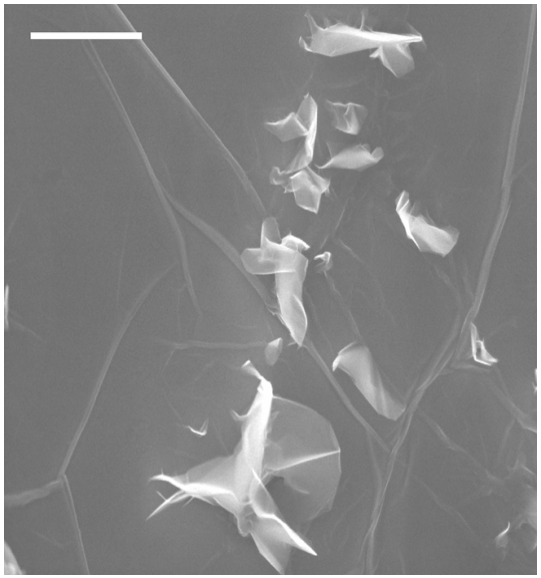
A. Malesevic et al., Nanotechnology, in press 2008

Few layer graphene growth mechanism

SEM study







Scale = 1 µm

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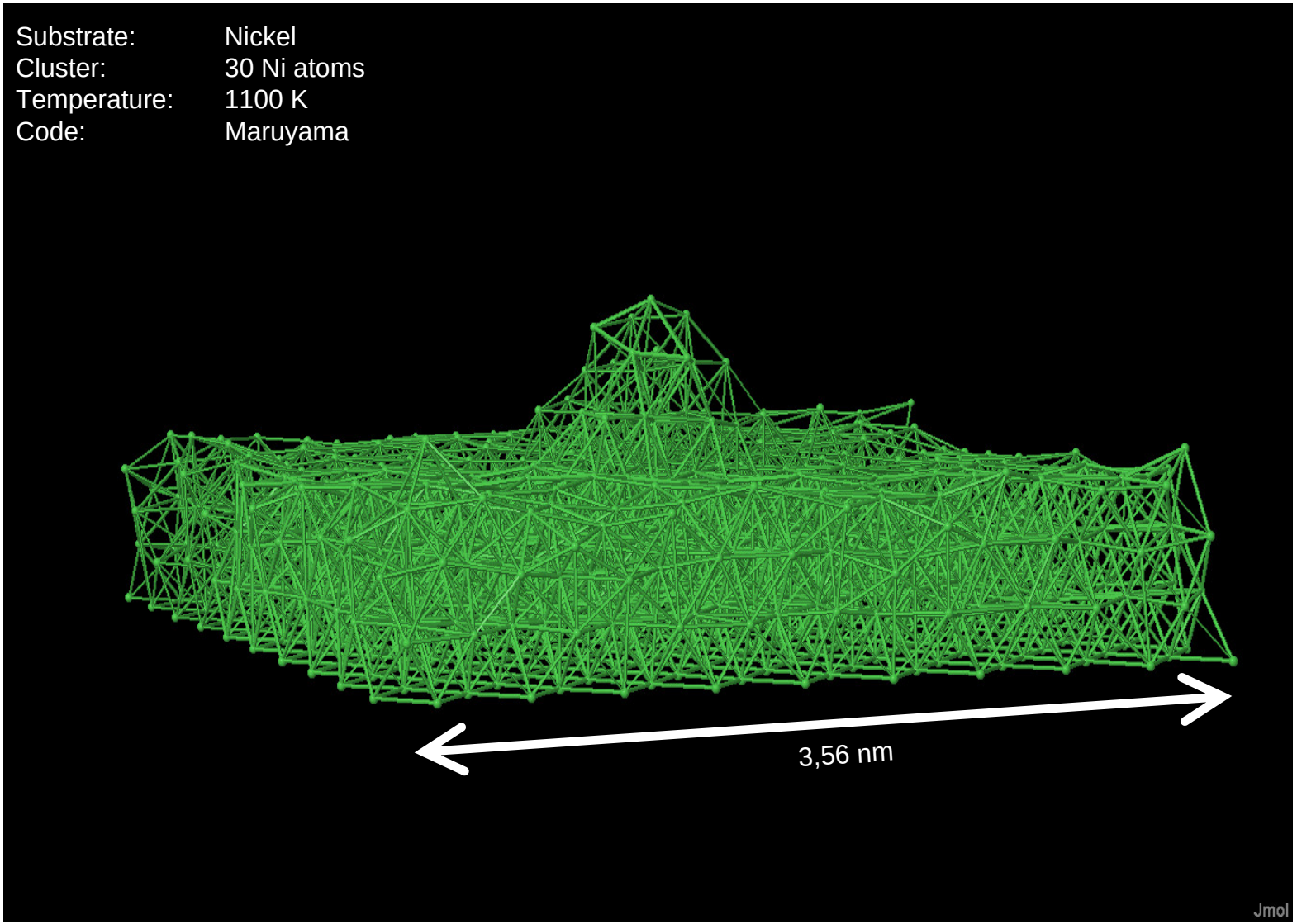
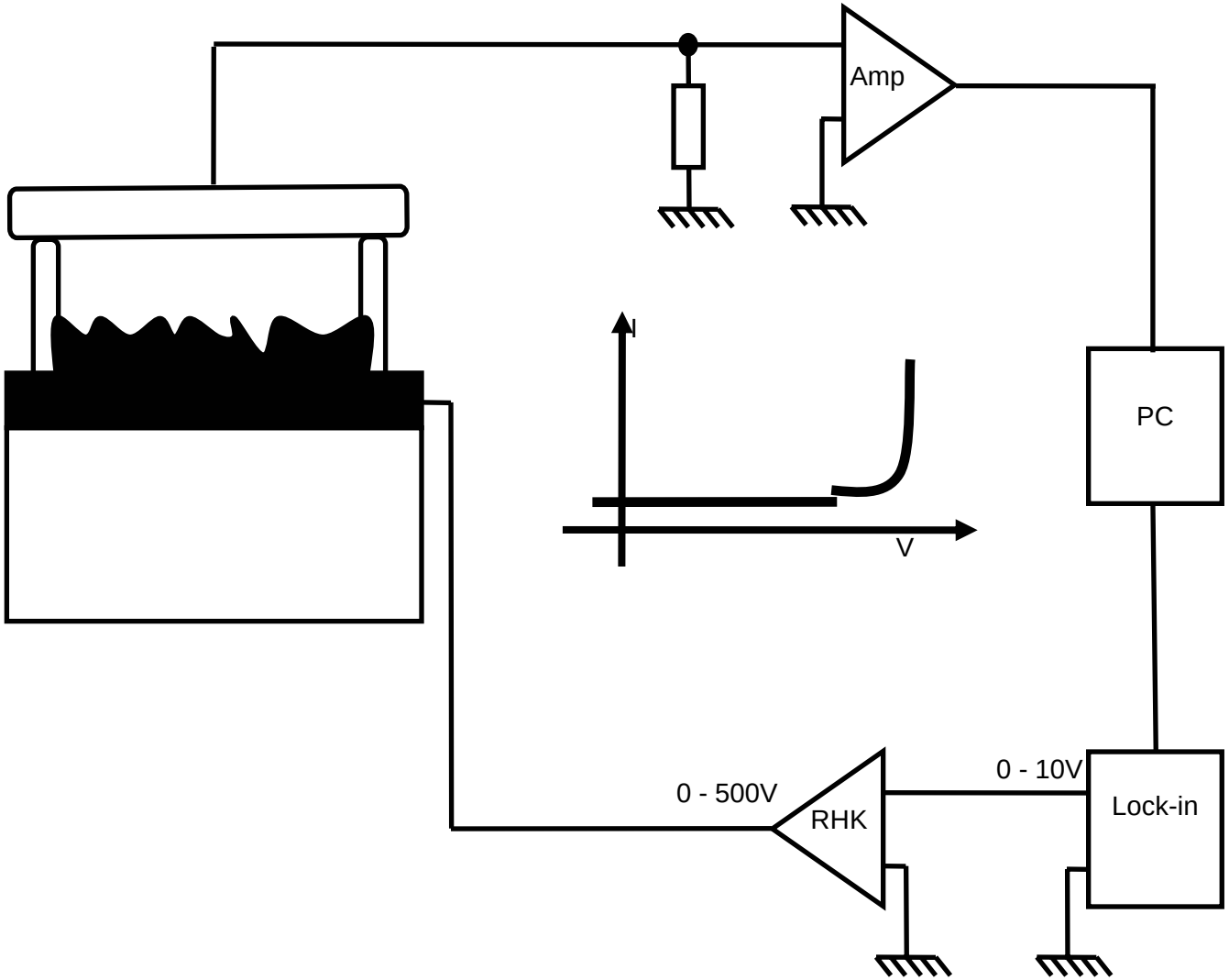
Few layer graphene growth mechanism

Modelling combination of molecular dynamics and monte Carlo simulations



Few layer graphene field emission

Field emission experimental results



Few layer graphene field emission

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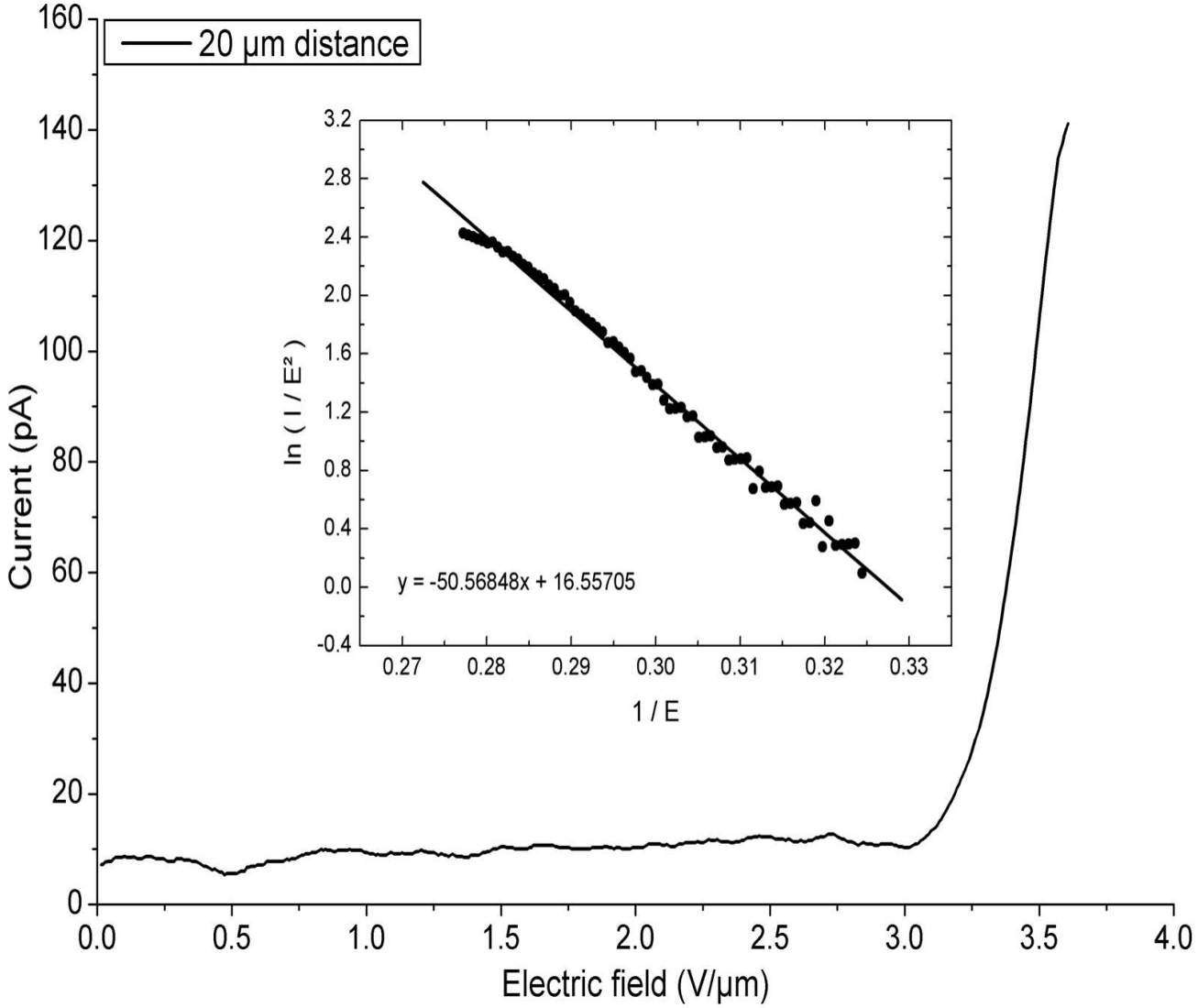
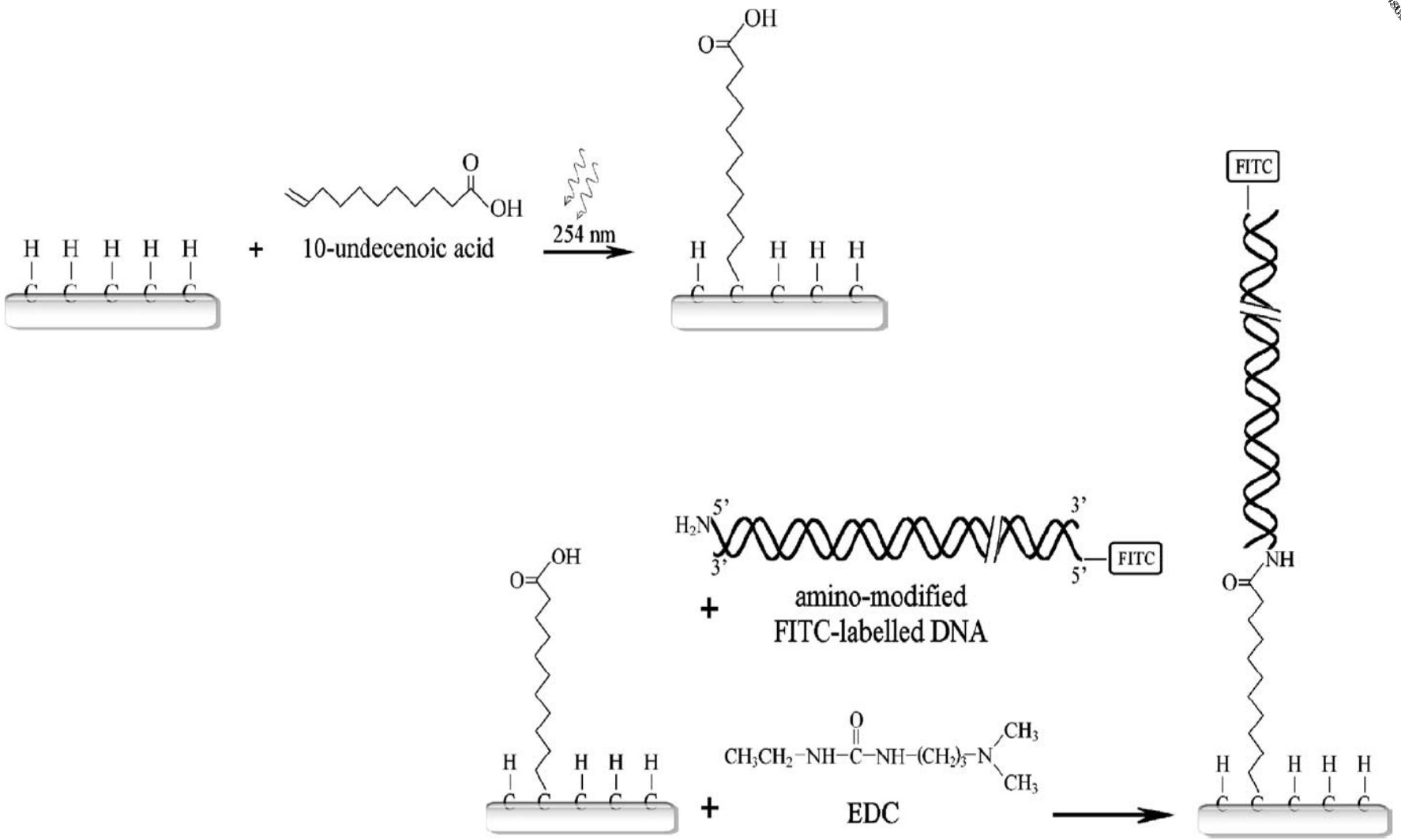


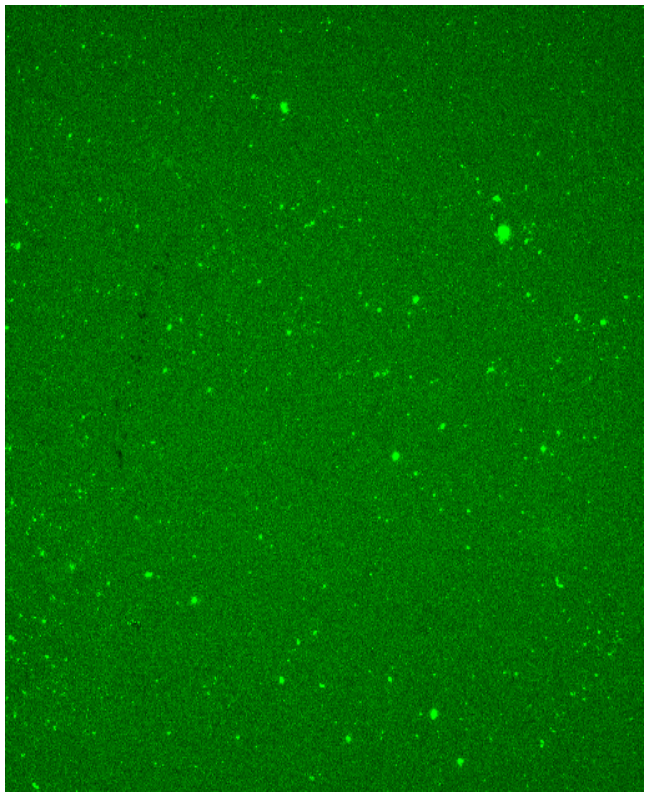
Bioactivation with ss-DNA

Two-step chemical functionalisation

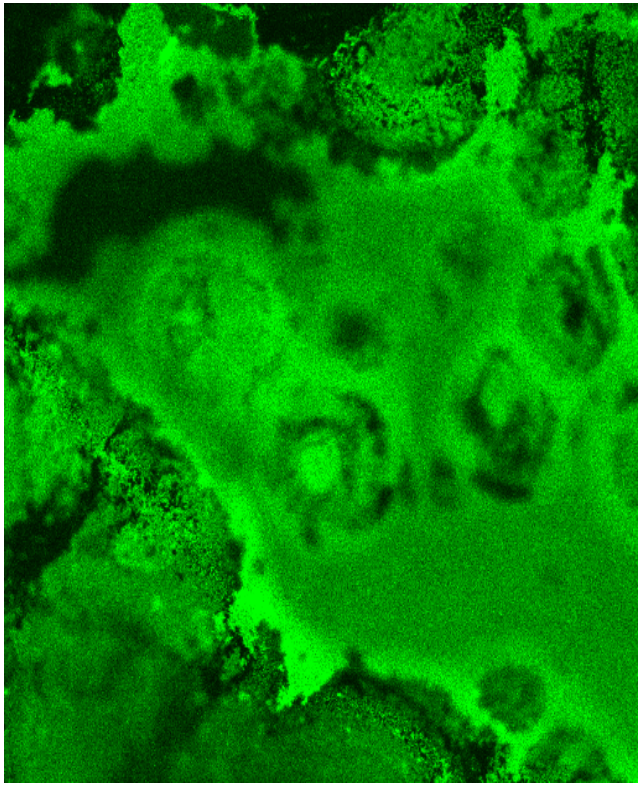


Bioactivation with ss-DNA

Confocal fluorescence microscopy



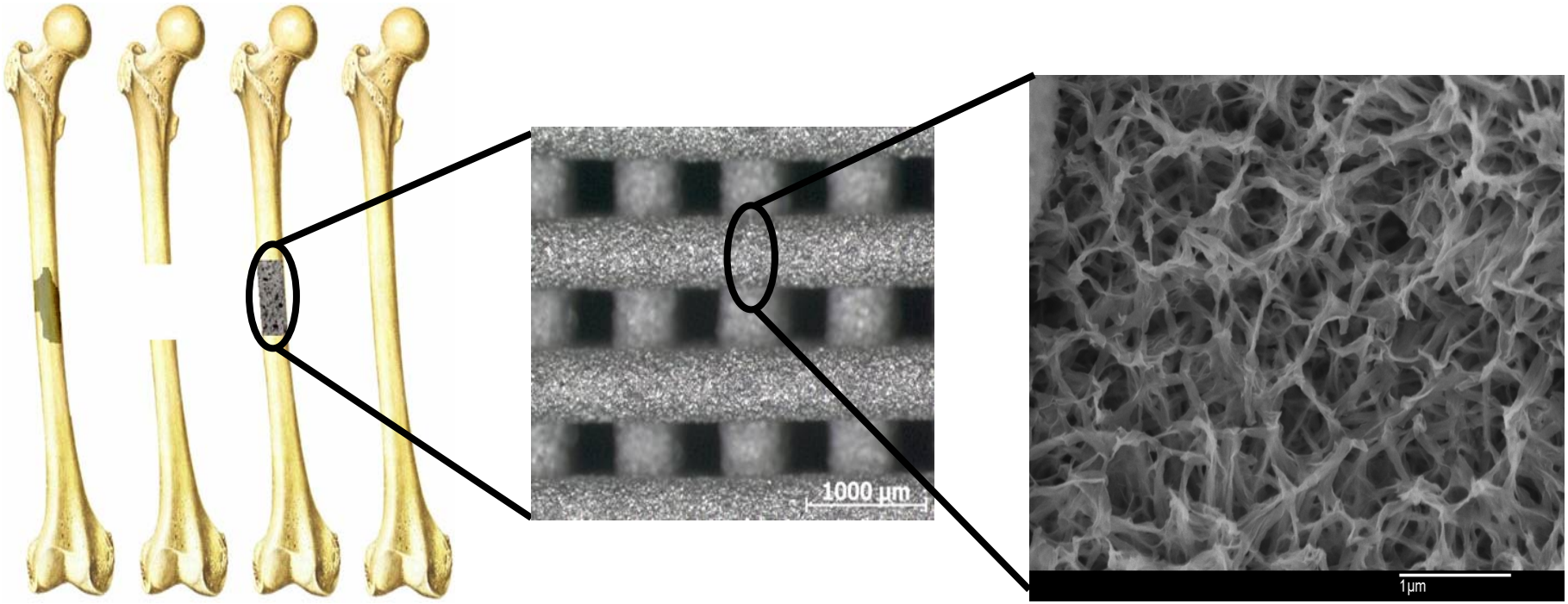
Si



Quartz

Titanium scaffolds for tissue regeneration

Principle

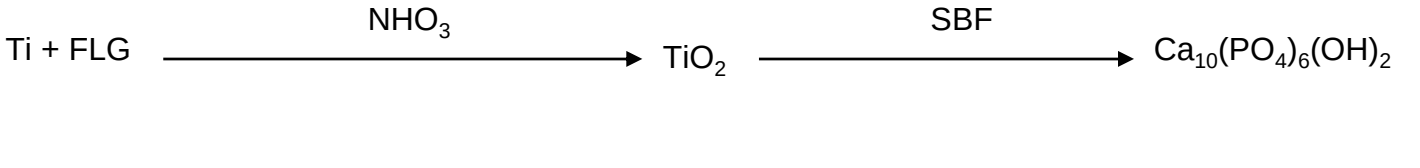


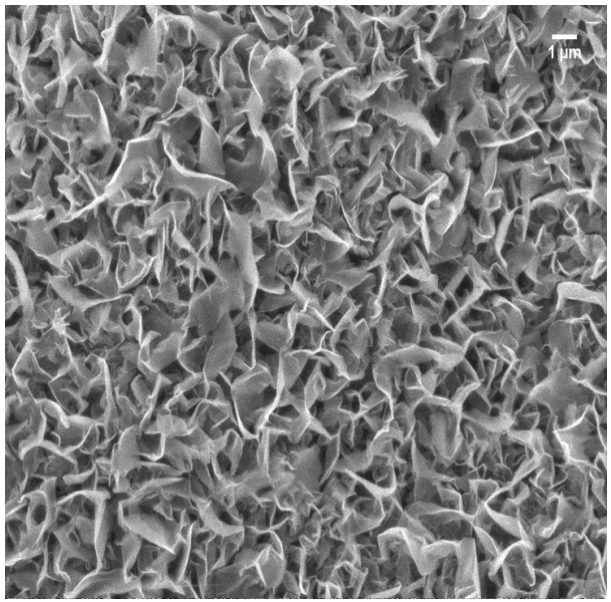
$$Ti \xrightarrow{NaOH} Na_2Ti_5O_{11} \xrightarrow{SBF} Ca_{10}(PO_4)_6(OH)_2$$

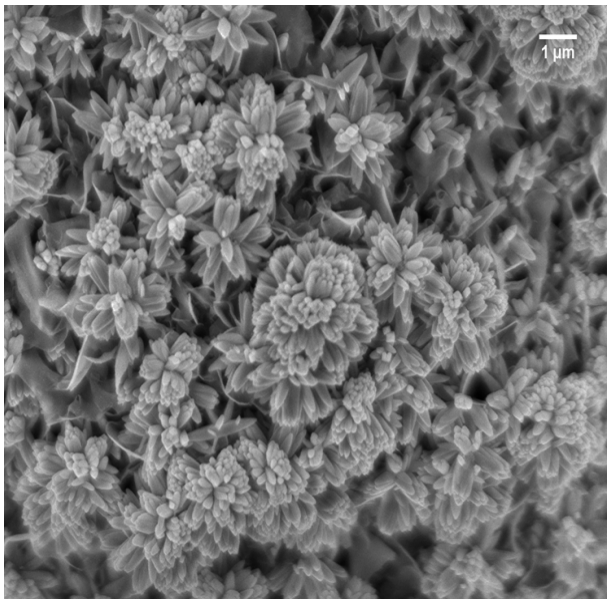
$$Ti \xrightarrow{PECVD} Ti + FLG \xrightarrow{NHO_3} TiO_2 \xrightarrow{SBF} Ca_{10}(PO_4)_6(OH)_2$$

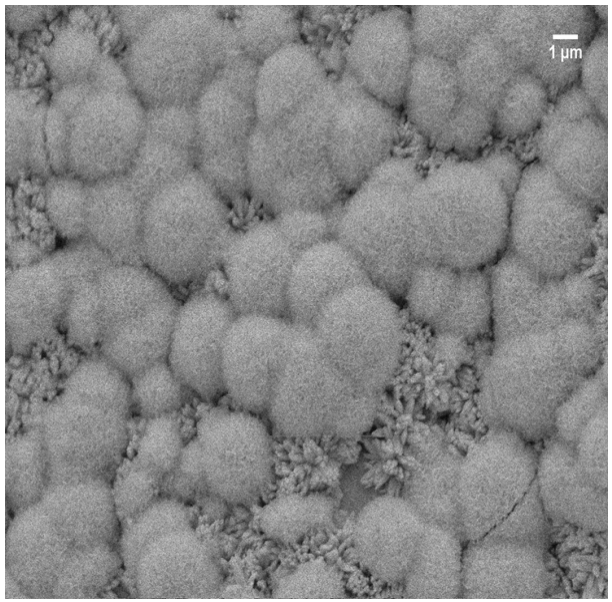
Titanium scaffolds for tissue regeneration

SEM results



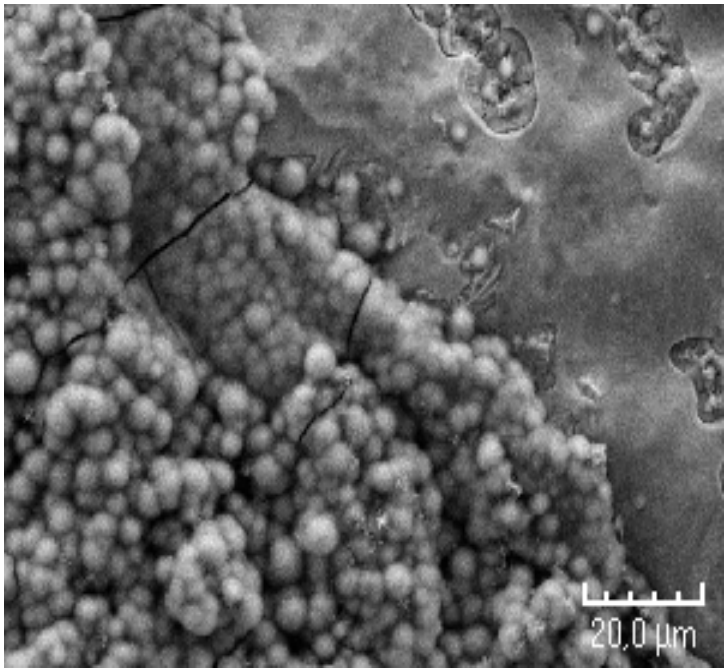






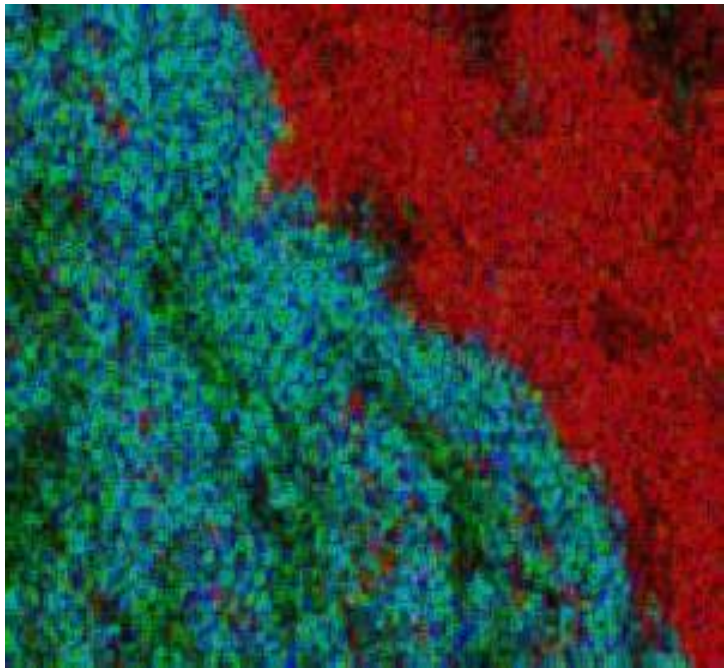
Titanium scaffolds for tissue regeneration

Material analysis



Top view SEM

Morphology



Electron diffraction mapping

RGB Comp Ti-Ca-P

Outlook & Conclusions

- ☑ MW PECVD Synthesis of FLG:
  - No catalyst required
  - Compatible with industrial techniques
- ☑ Properties of as grown flakes:
  - 4-6 layers thick
  - Highly crystalline
  - Few defects
- ☑ Three step growth mechanism
- ☑ Potential applications:
  - Promising field emission behavior
  - Potential DNA biosensor devices
  - Titanium scaffolds for tissue regeneration

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