Centro di ricerca per le Nanotecnologie applicate all'Ingegneria della Sapienza

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GraphITA,
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Effect of the synthesis parameters on the dc resistance of graphite nanoplatelets thick films

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GraphITA

Outline

- Synthesis of GNPs via Thermal Exfoliation
- Fabrication of GNPs thick films
- SEM and AFM characterizations
- FTIR spectroscopy of GNP-based foils
- DC conducivity measurements
- Conclusions

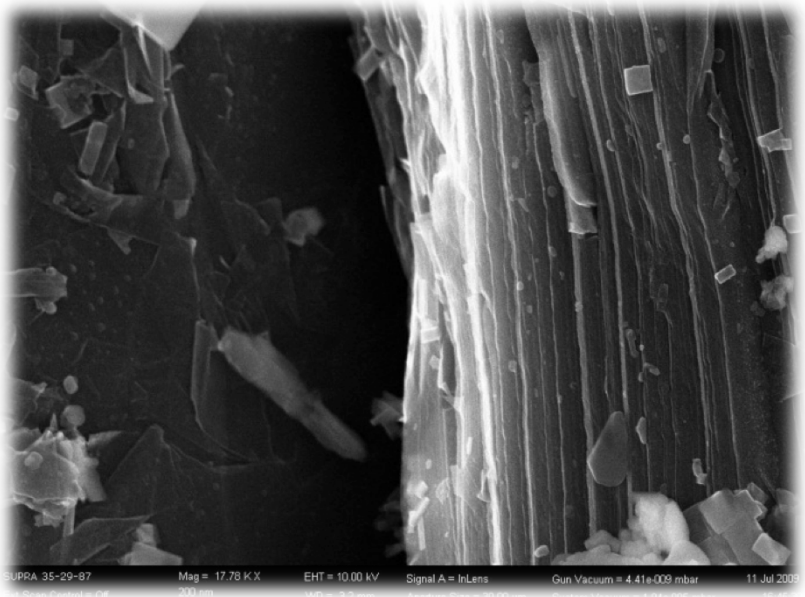
Graphite intercalation compounds (GIC)

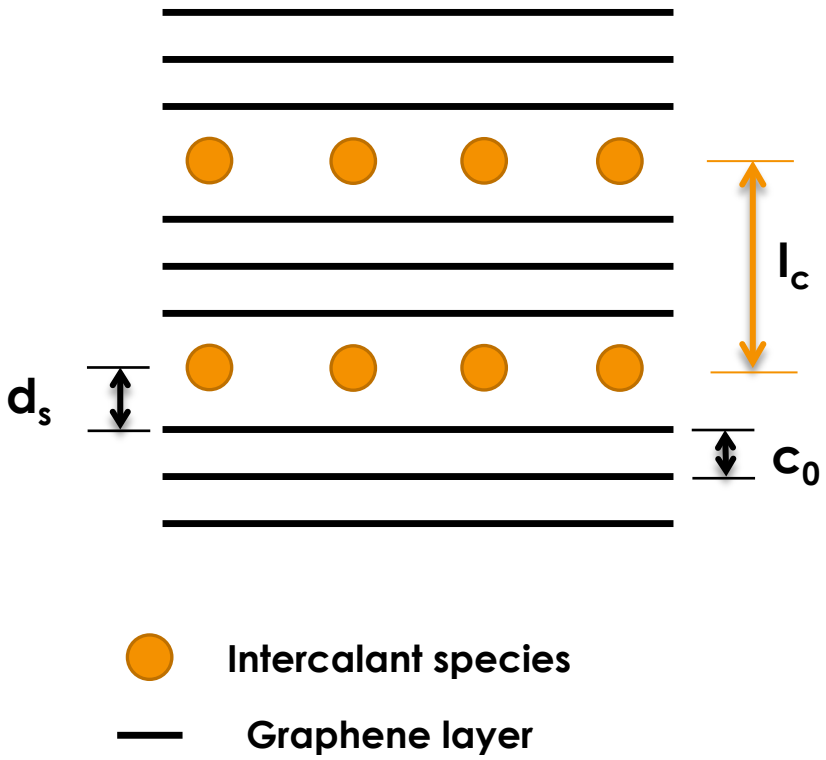
- **1841** GICs first synthesized (with Potassium as the intercalant) [1]
- **1859** Brodie prepared the first graphitic acid (graphite oxide)
- **1898** Staudenmeier improved the Brodie process using sulfuric acid
- **1957** Hummers and Offemann further enhanced the technique efficiency, considerably reducing the time required for the whole process

[1] Schafhautl, 1841

Graphite intercalation compounds are formed by the insertion of atomic or molecular layers of a different chemical species called the intercalant between layers n a graphite host material

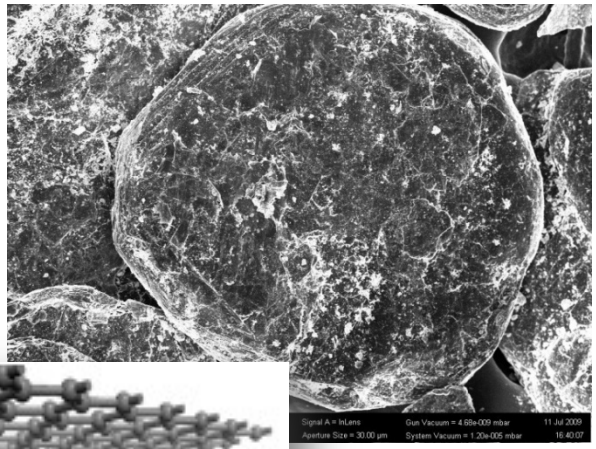
GIC structure

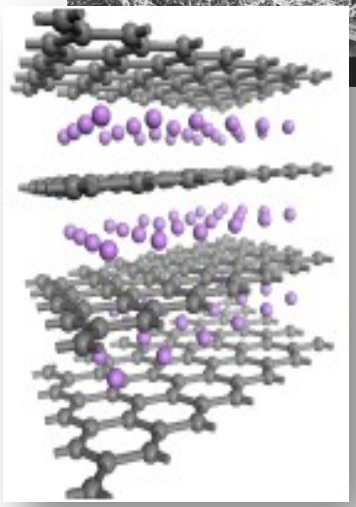




The stage index *n* can be extracted from the relation $I_c = (n-1)c_0 + d_s$

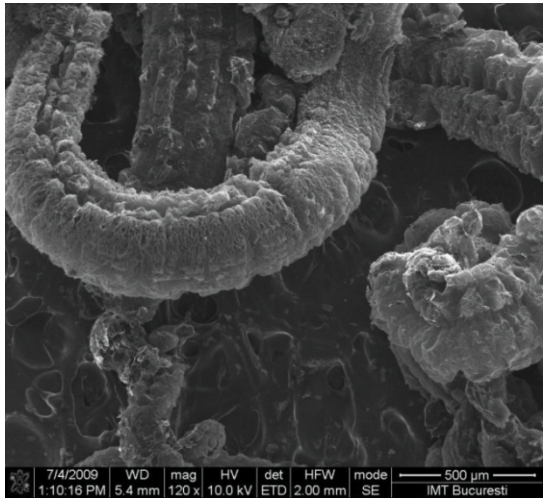
Thermo-chemical Exfoliation





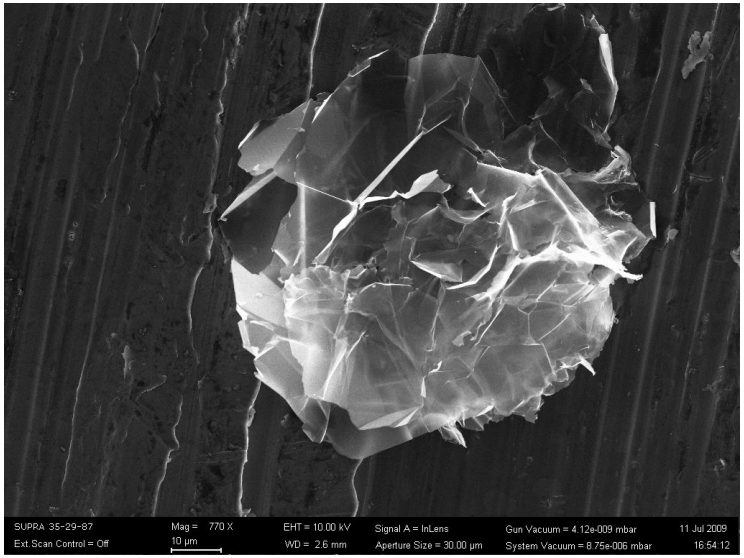
GIC flake

+ thermal shock



+

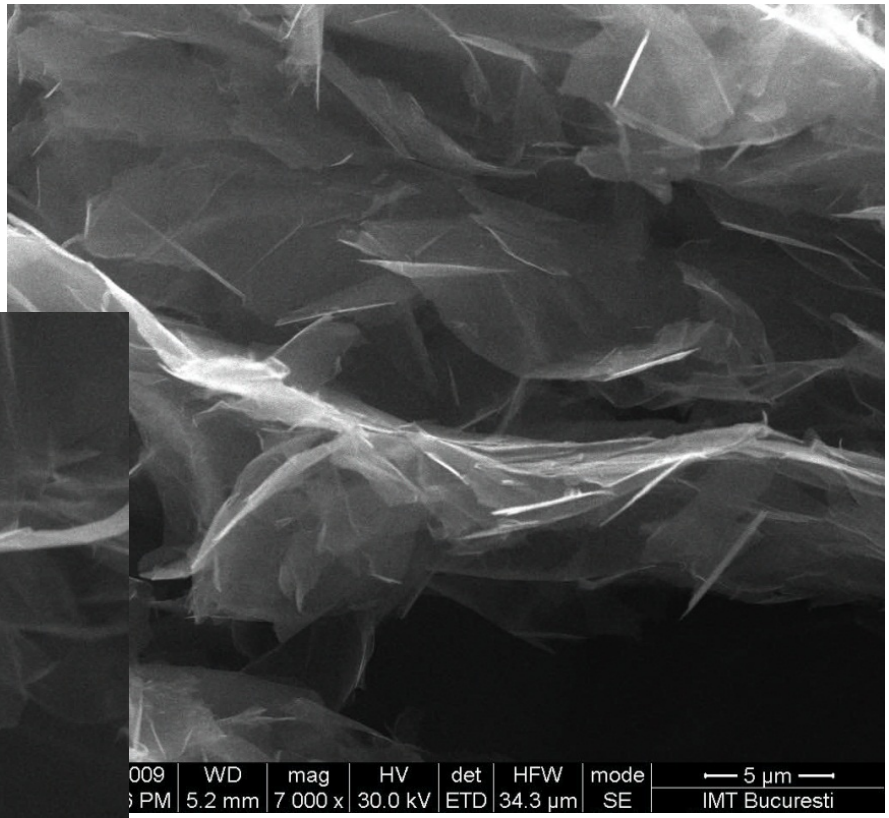
Ultrasonication

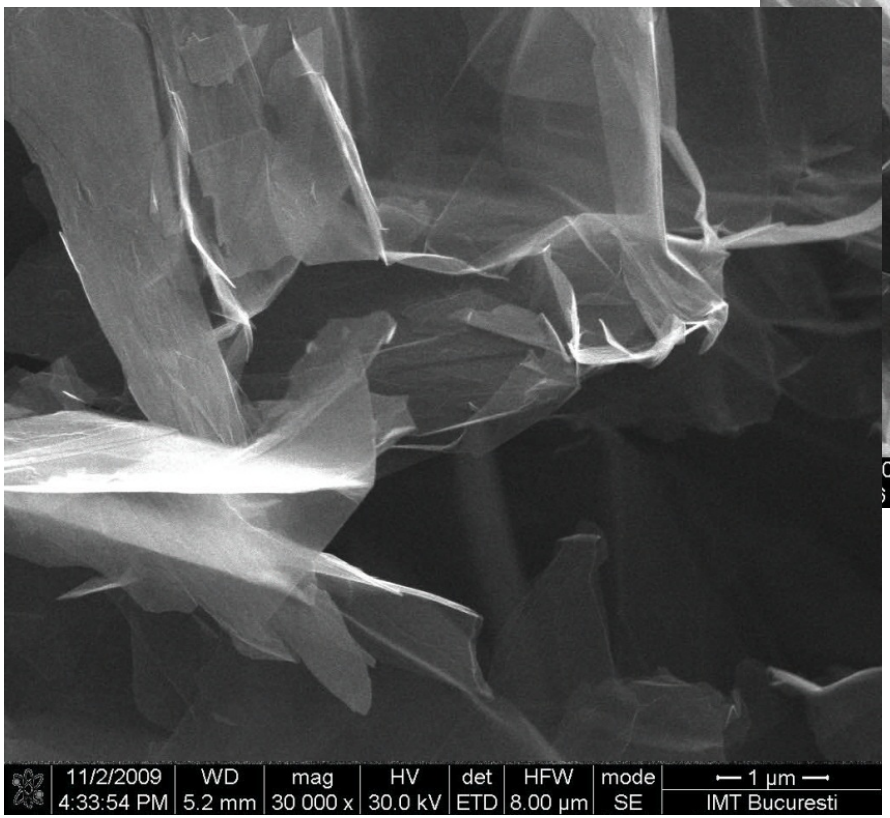


Expansion conditions

TEMPERATURE	EXPANSION TIME			
250°C		15s	30s	60s
500°C	5s	15s	30s	60s
750°C	5s	15s	30s	60s
1050°C	5s	15s	30s	50s
1150°C	5s	15s	30s	60s
1250°C	5s	15s	30s	

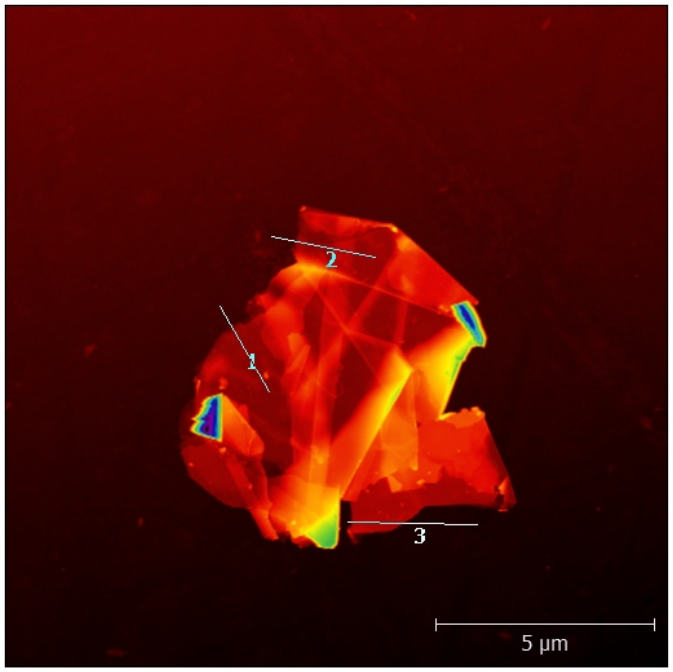
SEM imaging

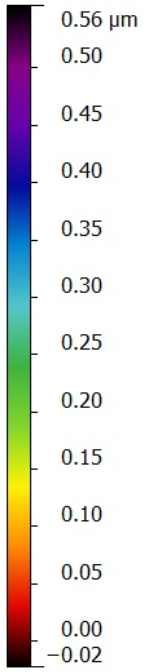


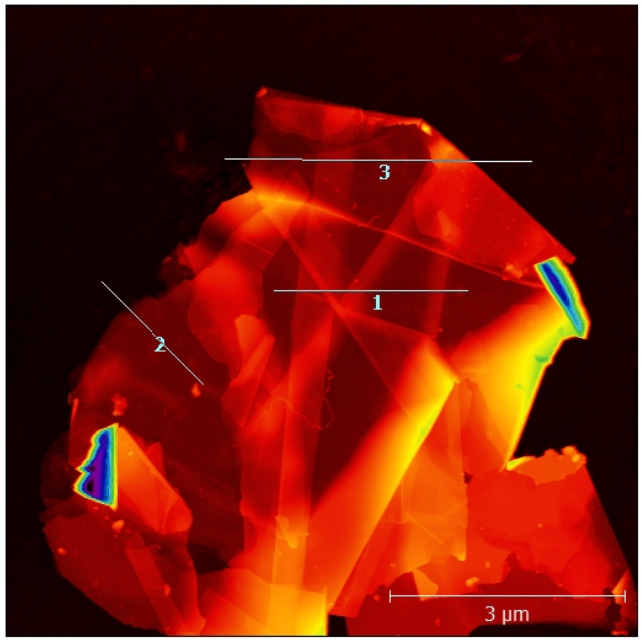


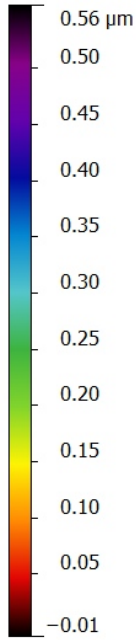
SEM Images courtesy of
Dr A.Dinescu, IMT Bucharest

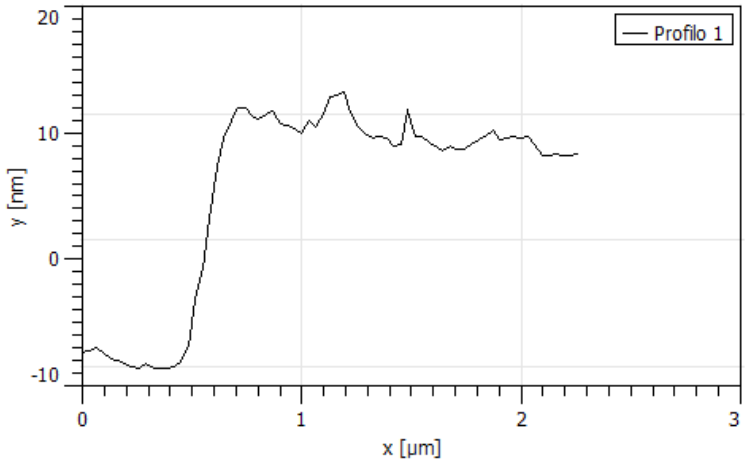
AFM imaging 750°C-30s

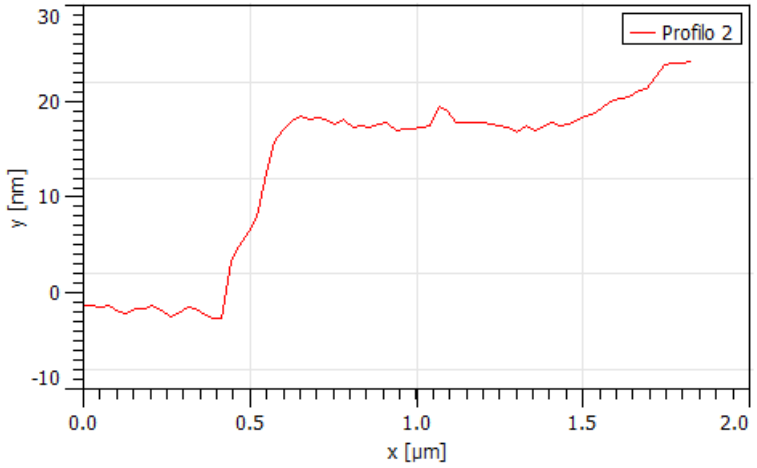




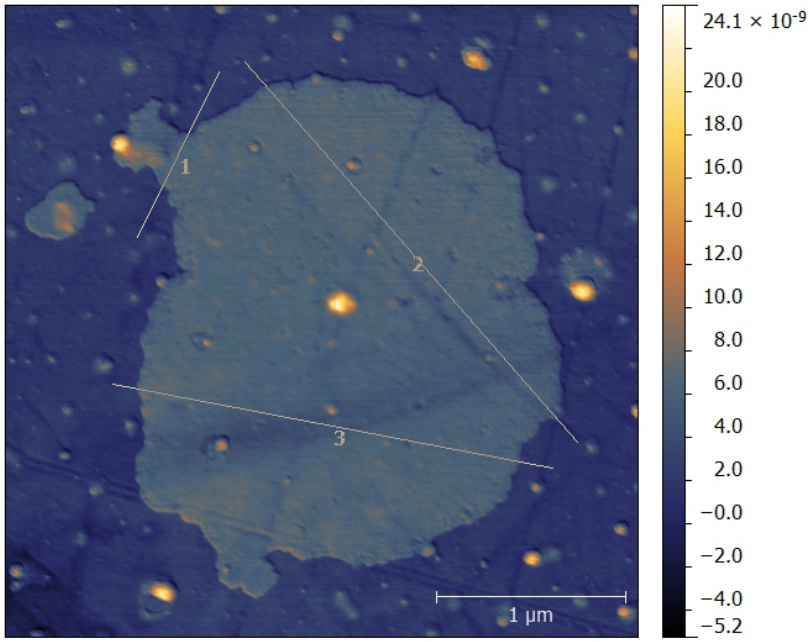


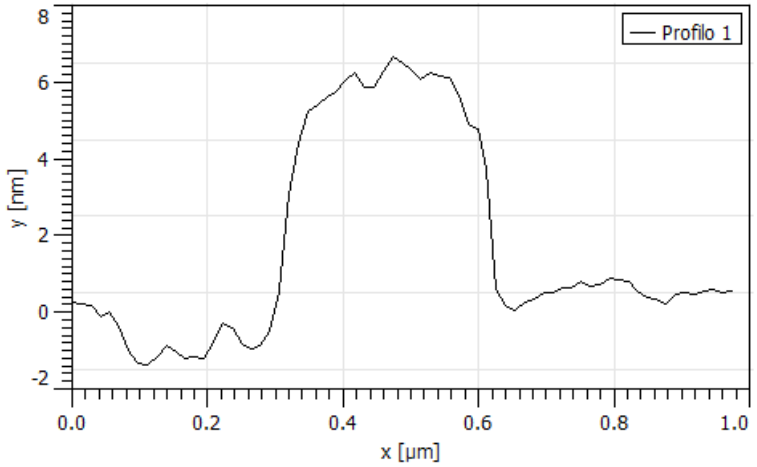


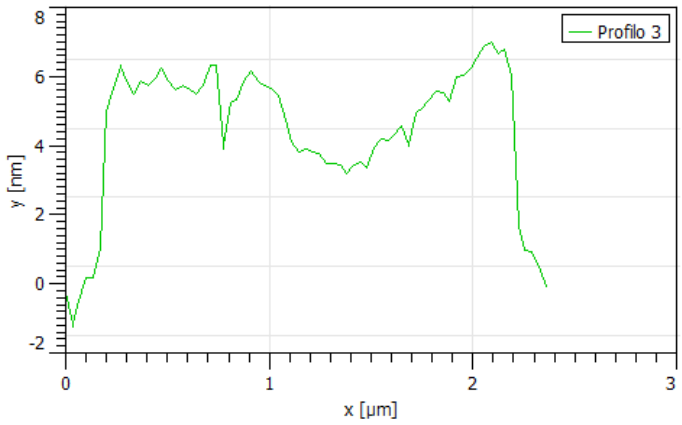


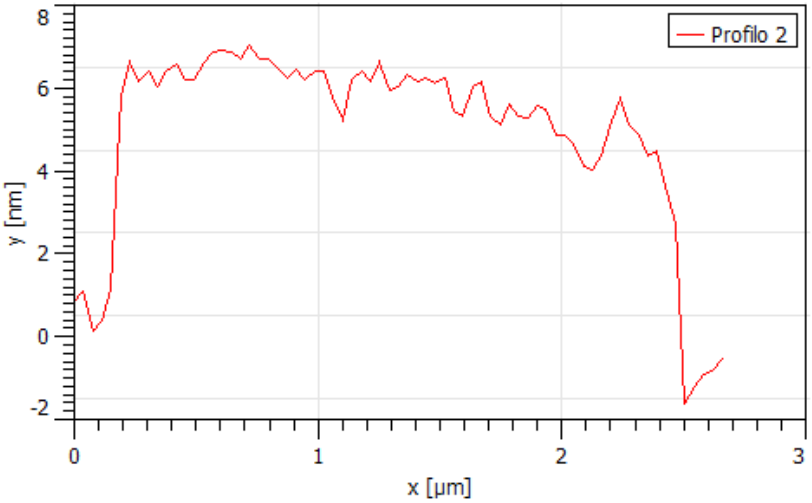


AFM imaging 1250°C-30s

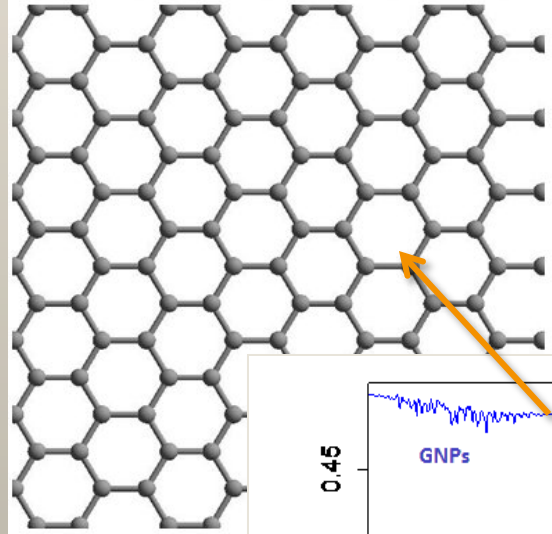


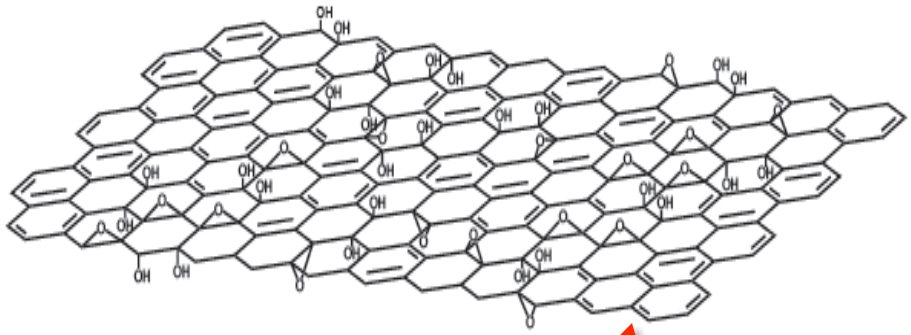


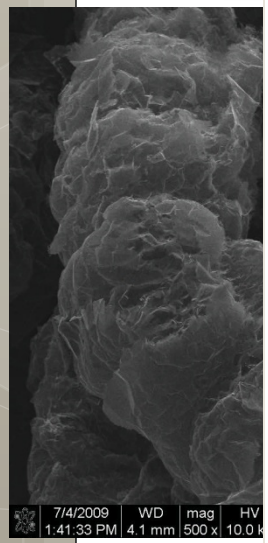


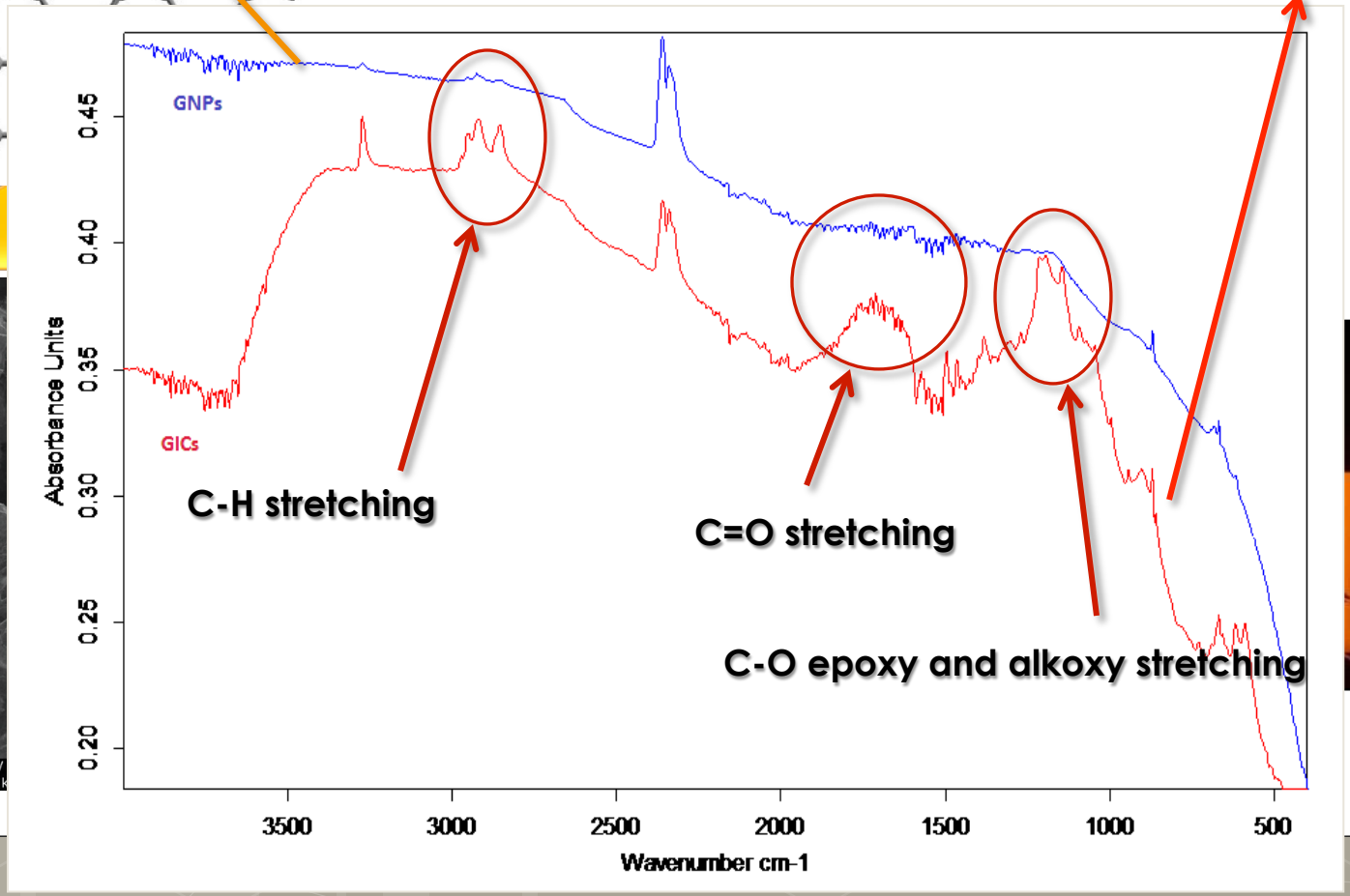


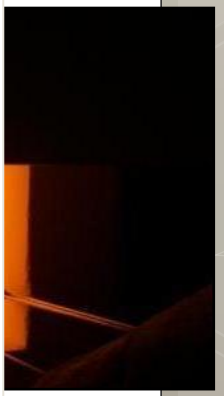
FTIR spectroscopy on GICs before and after thermal expansion











GNP films preparation

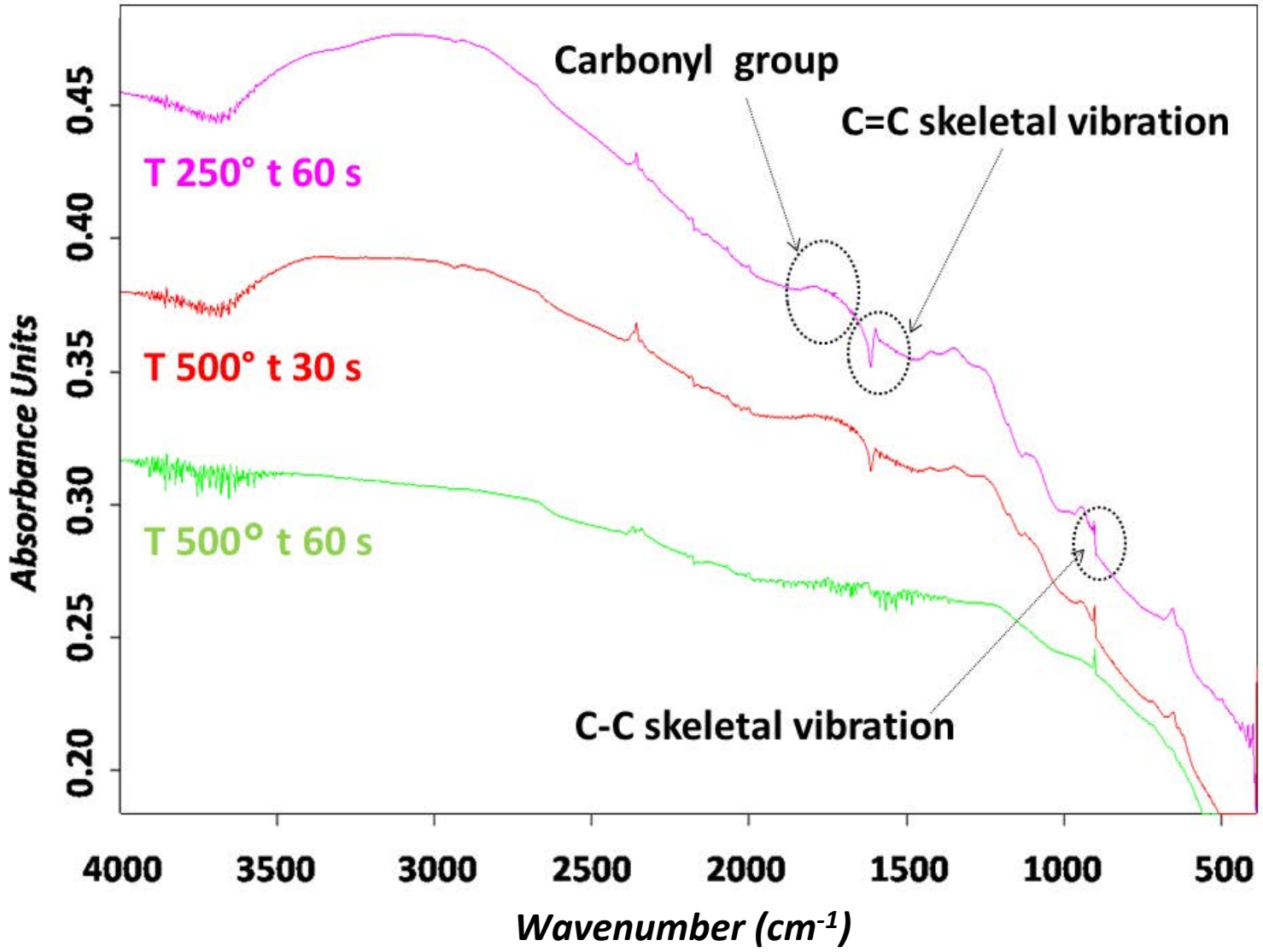
Worm-like graphite

Ultrasonication

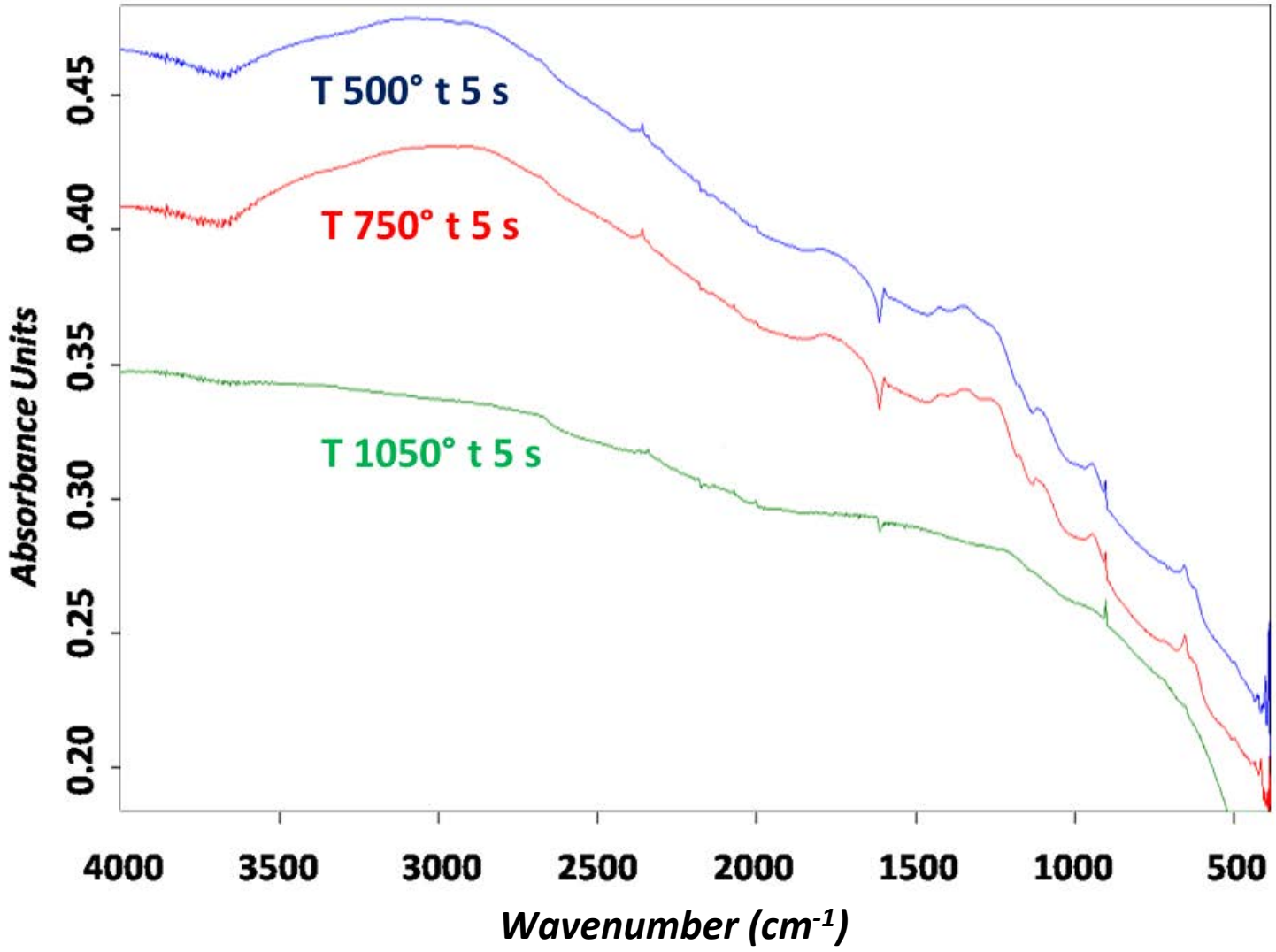
Vacuum filtration

GNP film

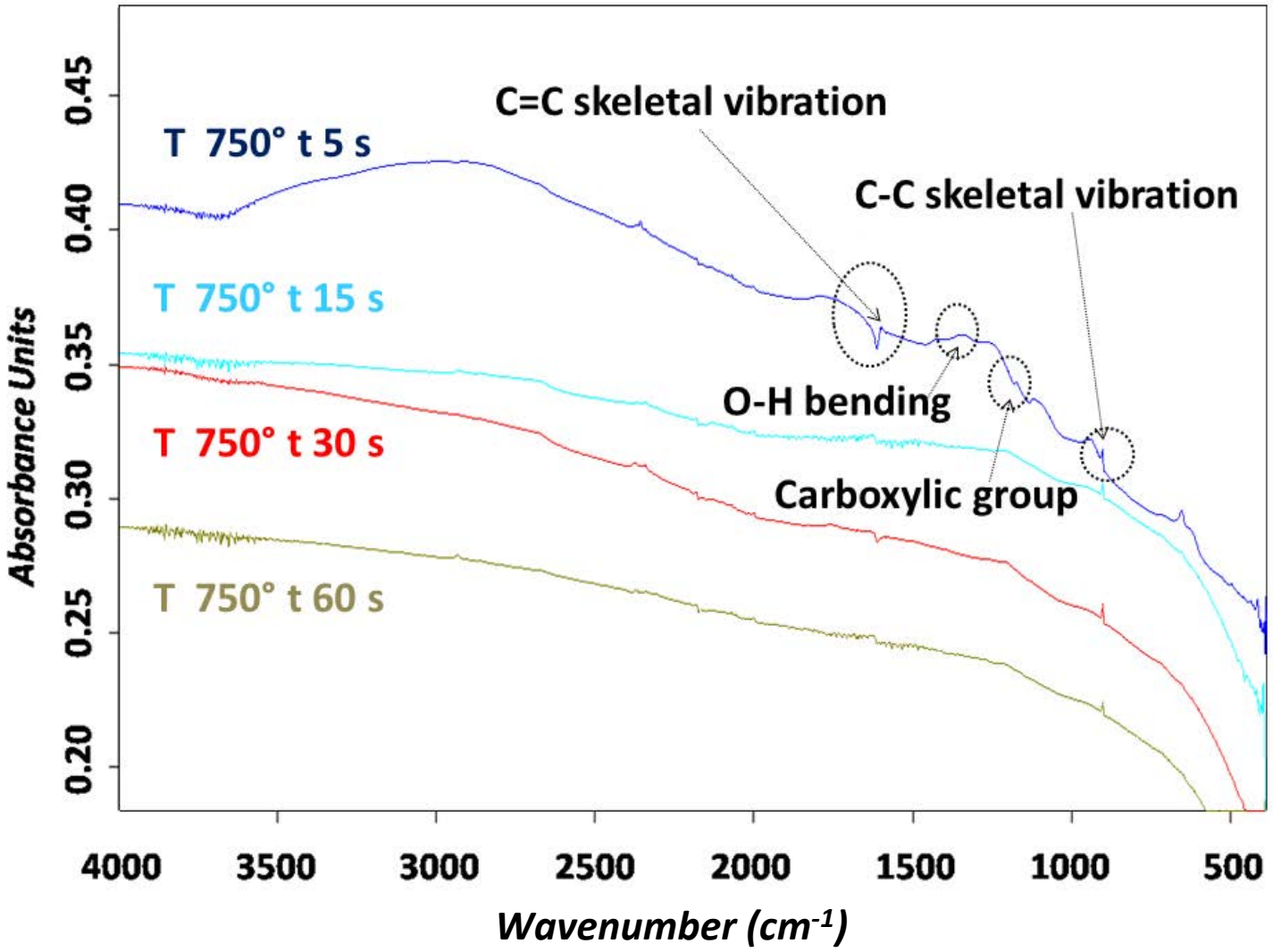
FTIR spectroscopy



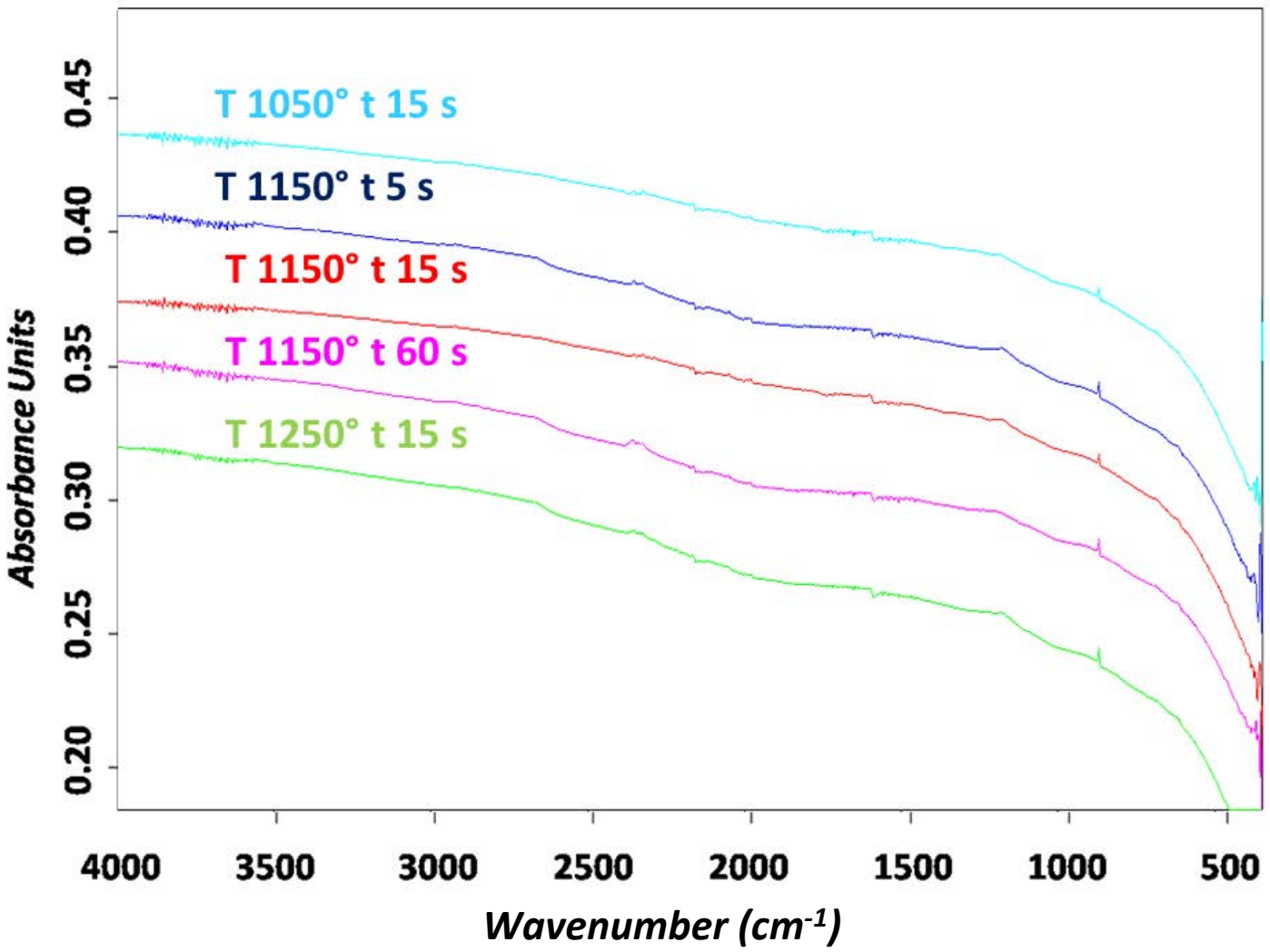
Effect of the expansion temperature



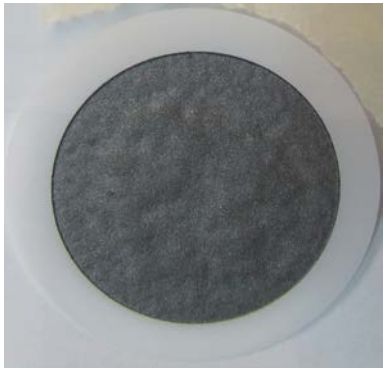
Effect of the expansion time

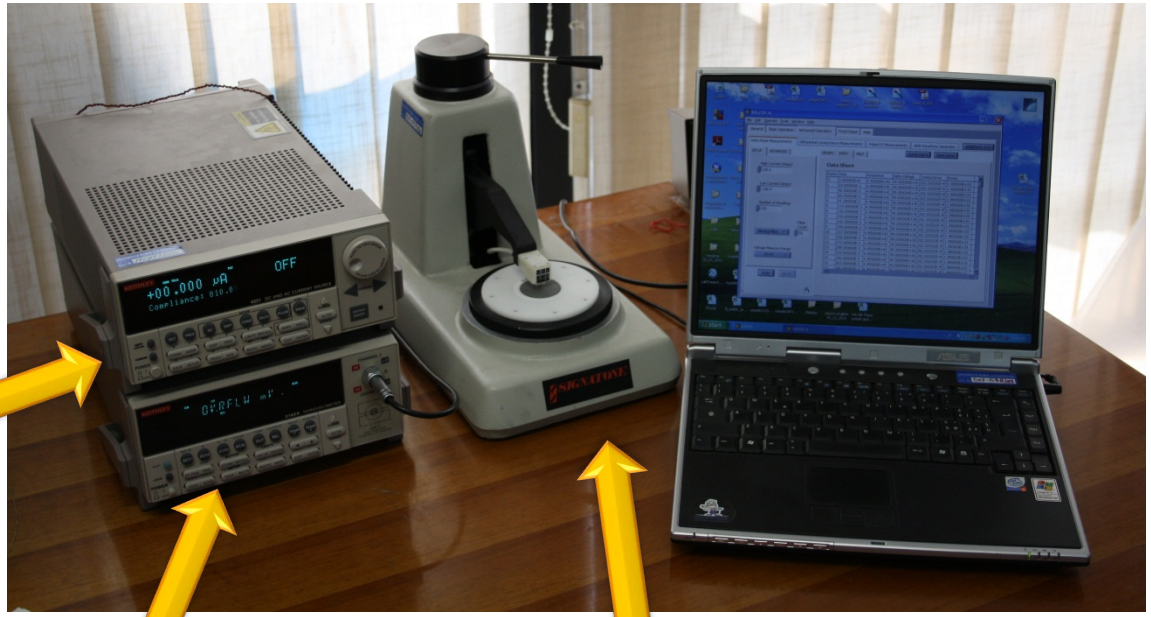


High temperature expansion



DC measurements experimental setup





$$R_s = \pi / \ln(2)\ V/I\ [\Omega/\text{square}]$$

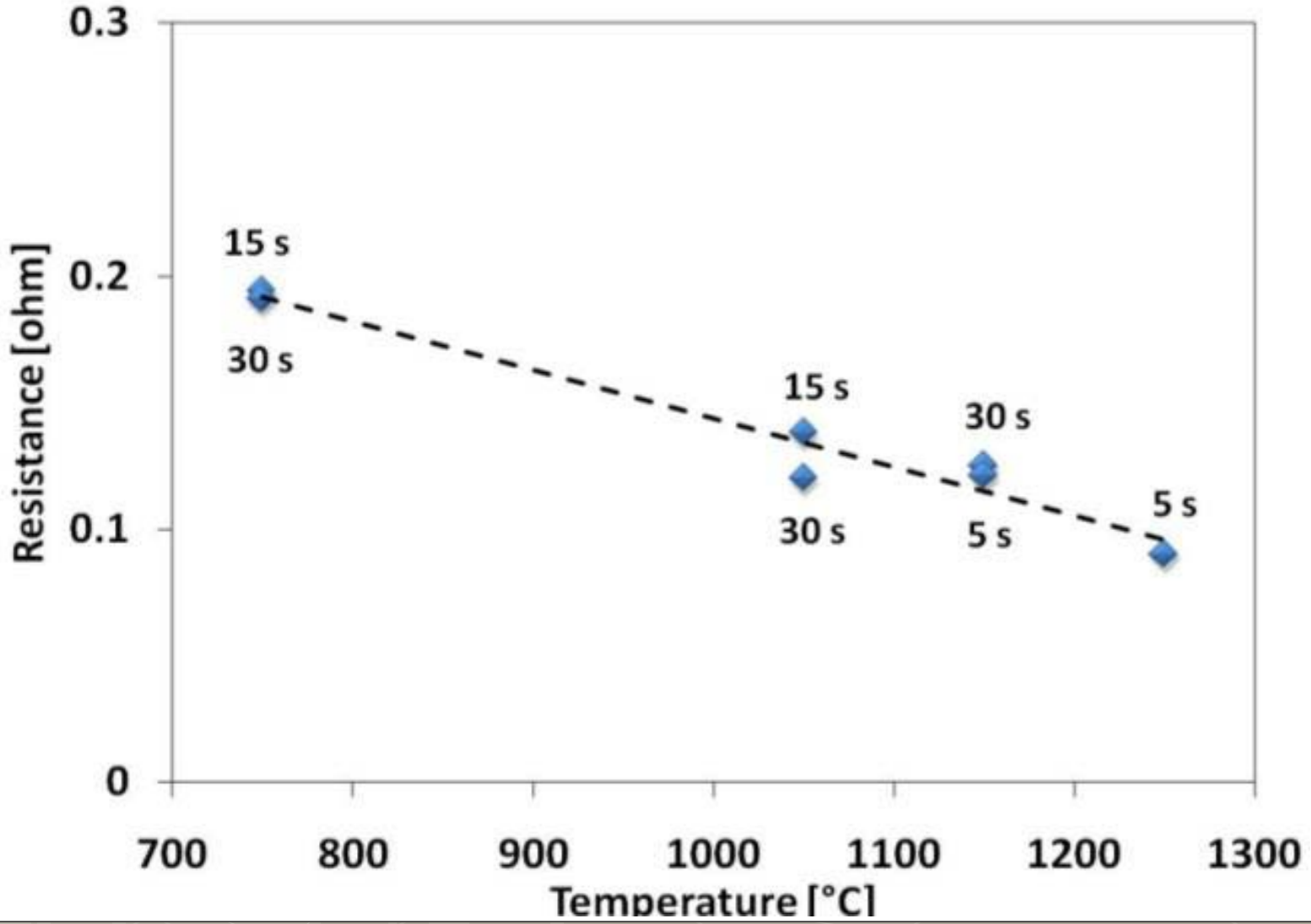
$$\sigma = 1/R_s\, t\ [S/m]$$

DC measurements results

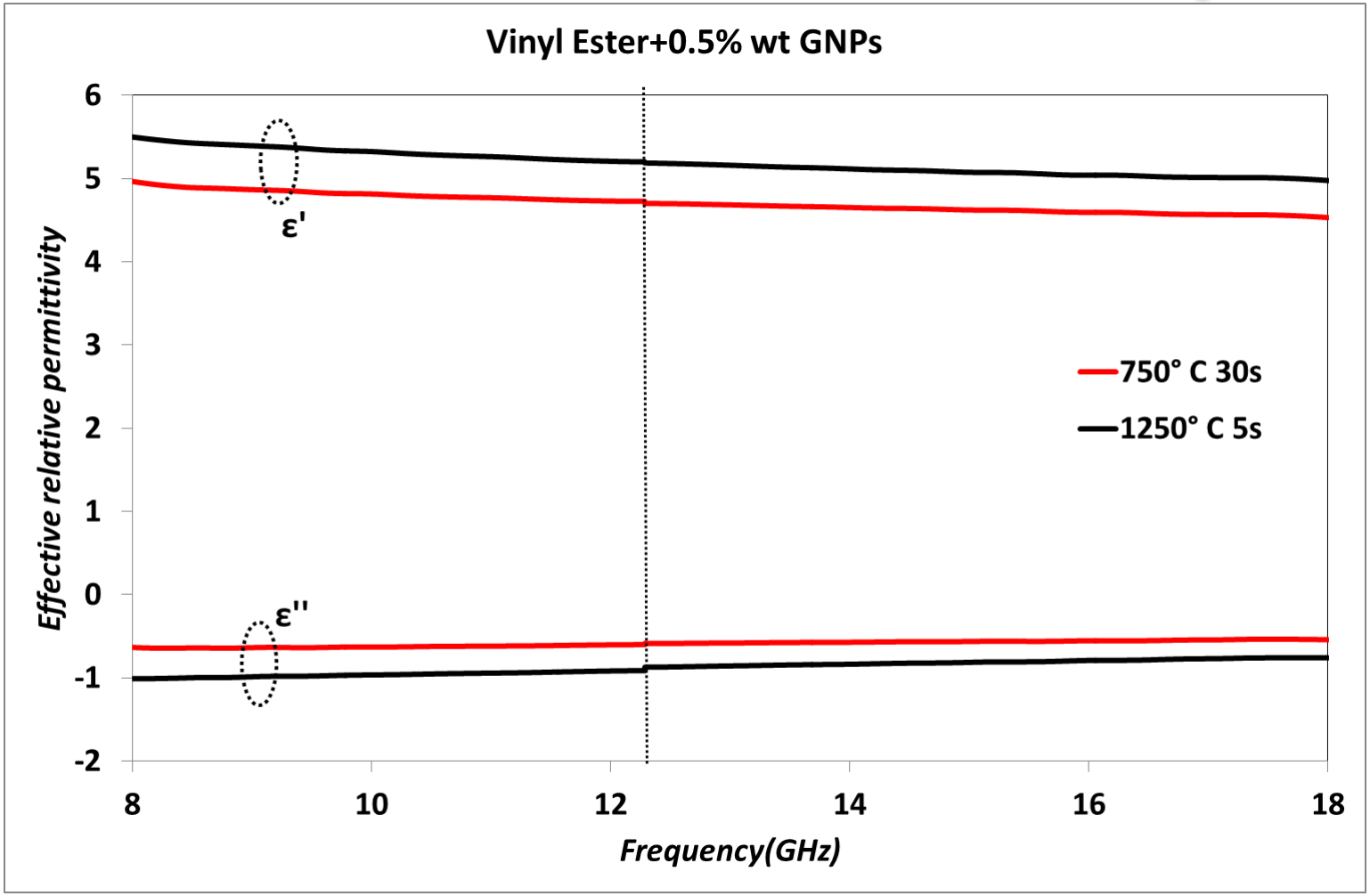
Expansion conditions	Resistance (V/I) [Ω]	Conductivity* [S/m]
T 750° t 15s	0.194	5808
T 750° t 30s	0.191	5919
T 1050° t 15s	0.138	8063
T 1050° t 30s	0.120	9273
T 1150° t 5s	0.125	9627
T 1150° t 30s	0.121	9196
T 1250° t 5s	0.090	12393

*Extimated assuming an average film thickness of 200 μm

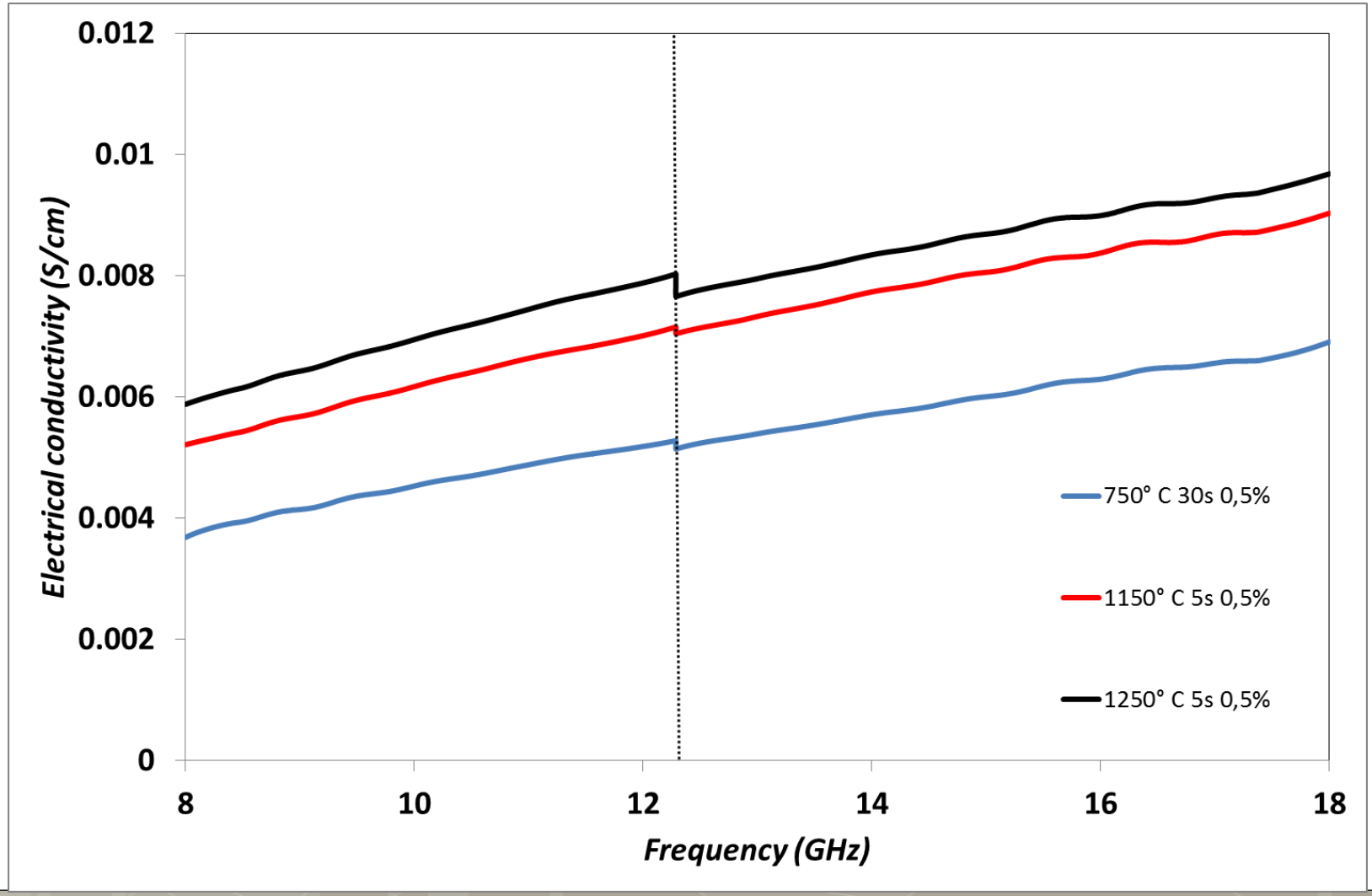
Resistance vs expansion temperature



Effect of the synthesis conditions on the EM performance of GNP-based nanocomposites



Electrical conductivity of nanocomposites loaded with 0.5% wt GNPs



Concluding remarks

- The morphological and physical properties of GNPs produced by TCE of GICs are strongly affected by expansion temperature (T) and time (t)
- FTIR spectra are nearly independent from those parameters for T>1000°C
- Proper choice of the processing conditions enables tailoring of the electrical properties
- GNP-filled composites with tailored EM properties can be realized by properly choosing the process parameters for the GNP synthesis

Thanks for your attention