Contact angles have also been measured and fitted with a normal distribution. Samples 1 and 2 exhibit high contact angle of 118.9° and 117.4°, which can be translated to a low wettability for these temperatures.

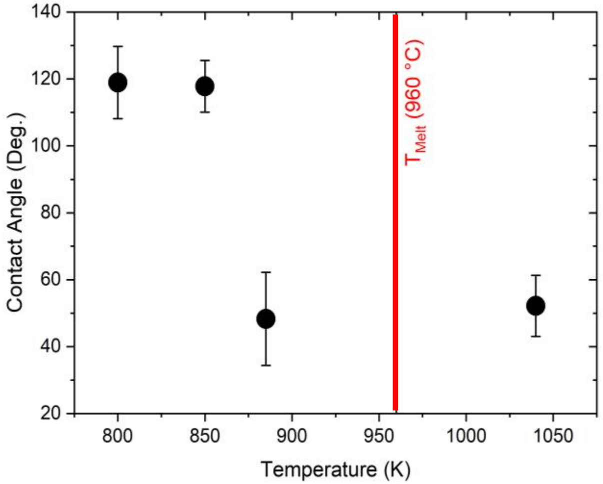

Figure 4: Average nanoparticles contact angles.

On the contrary, samples 3 and 4 wet the substrate, having average contact angles of 48.3° and 52.2°. This decreasing in the mean contact angle has been attributed to Si diffusion from the substrate to the Ag NPs, which lowers the free surface energy at the substrate nanoparticle interface and the contact angle as consequence.

This behavior has been confirmed by EDX compositional analysis. In fact, while samples 1, 2 and 4 have high Ag content, related to their sizes, sample 3 has an intense Si peak, related to a high silicon concentration in the particle. Similar results had been obtained by other authors, obtaining an Ag-Si alloy formation, simulated for Ag-SiC pseudo-binary systems.

Lastly optical properties have been studied measuring the absorbance and transmittance spectra, which shows a peak in light absorption and a minimum in transmittance at 460 nm, greater for each sample than the only SiC substrate.

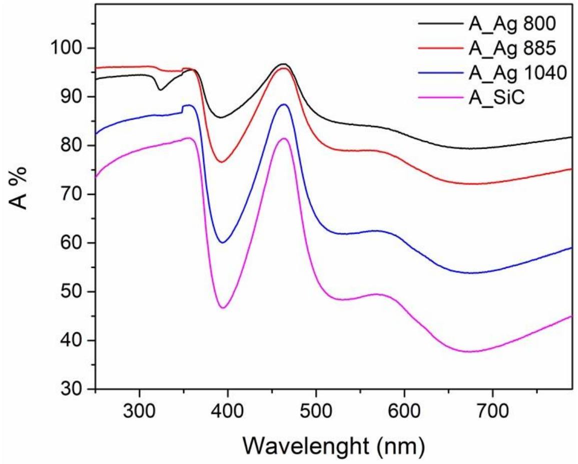

Figure 5: Absorbance spectra.

Conclusions and Future Perspectives

Ag nanoparticles has been synthesized on a 4H-SiC substrate through dewetting process, a low cost and controllable technique that has proven to be a useful tool to study wetting properties of this noble metal on silicon carbide.

However, even if a good control on contact angle has been achieved, size dispersion is still too high.

For these reasons future studies should be focused on this problematic, studying the NPs morphology in patterned or template confined substrate. Moreover, photoluminescence and Raman spectra can be measured in order to study Ag NPs for optical application, in particular SERS.

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Master Degree in Physics

Domenico Irrera

Silver nanoparticles synthesis on silicon carbide for future applications

Supervisor:

Prof. F. Ruffino

Co-Supervisor:

Dr. M. Censabella

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Introduction

Starting from '80s, metal nanoparticles (NPs) began to be studied and exploited in various field of research and application for their unique electrical and optical properties, in particular noble metals such as silver and gold, which present *Localized Surface Plasmon Resonance* (LSPR) in the visible electromagnetic range and can be tuned by adjusting the NPs size and shape.

Nanomaterials based on *Silicon Carbide* (SiC), a wide gap semiconductor with peculiar characteristics such as high thermal conductivity, phonon frequency, breakdown voltage and the possibility to be synthesized in more than 200 stable structures called polytypes, each different for the Si-C staking order. For these properties, 4H-SiC systems have been recently coupled with Ag nanoparticles to increase the photoluminescence *Surface Enhanced Raman Spectroscopy* (*SERS*), making them excellent candidate for photonic and optical applications.

Is then fundamental to study an efficient way to produce metal NPs on a 4H-SiC substrate with a controlled and defined morphology to exploit the plasmonic properties of these metallic nanostructures. Usually metal nanoparticles are produced in solution thought chemical reactions, laser ablation or by self-organizing process on a substrate.

This thesis work is focused on the morphology and adhesion properties of Ag nanoparticles obtained on a 4H-SiC substrate by dewetting process, starting from an Ag film, at different temperatures. In this case four samples have been synthesized at different temperatures, three under the melting temperature (800 °C, 850 °C, 885 °C) and one over (1040 °C). Dewetting processes are an easy way to produce NPs, which allow to obtain large scale productions and don't require hazardous products.

Thermal Process

An Ag thin film of 58 nm thickness, measured via *Rutherford Backscattering Spectrometry* (RBS), has been dewetted at the specific temperature, reached with thermal ramps of 10 °C/min, both in ascending and descending temperatures.

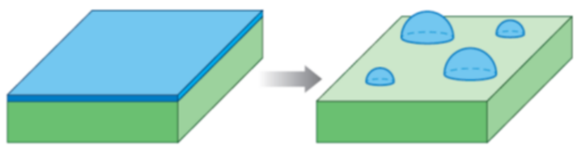

Figure 1: Dewetting process schematics

Obtained samples have been analyzed using *Scanning Electron Microscope* (SEM) images to obtain morphological informations on the contact angles and particles size.

Moreover *Energy Dispersive X-ray* (EDX) and *Uv-Vis spectra* has been acquired in order to obtain compositional and optical informations on the obtained particles.

Morphological Characterization

Size measurements have been obtained by taking the equivalent disk diameter, i.e the smallest circumference that contains the NP, and the obtained data had been fitted with a Lognormal distribution.

The results show a mean value of 122.4 nm, 169.1 nm, 153.2 nm and 885.7 nm for samples 1, 2, 3 and 4 respectively.

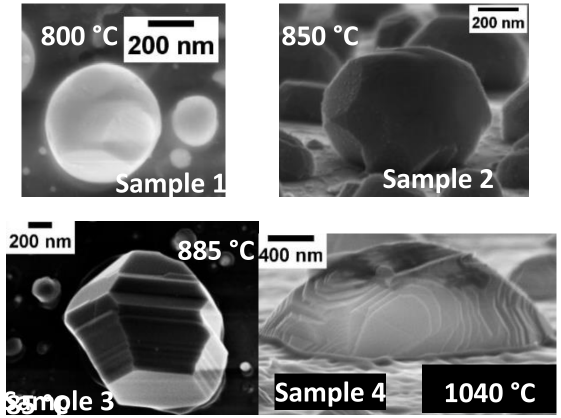

Figure 2: SEM images of each sample.

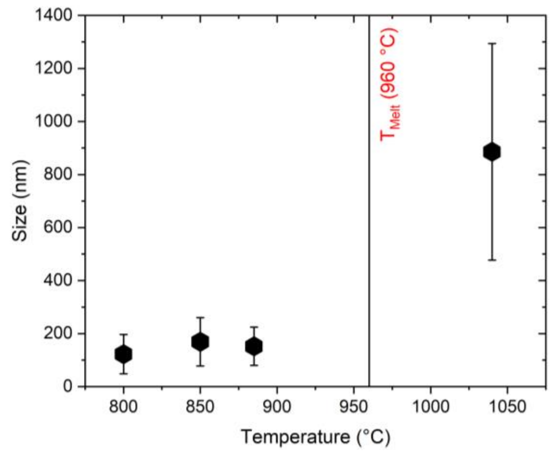

Figure 3: Average nanoparticles sizes.

However, each sample shows a size dispersion greater than 40%, common for self-assembly processes and observed by other authors. Moreover sample 1 shows an higher density, with a value of $1.145 \times 10^9 cm^{-2}$, to respect samples 2 and 3, which both possess a value of $0.596 \times 10^9 cm^{-2}$. On the other hand sample 4 has the lowest value of $0.036 \times 10^9 cm^{-2}$, in agreement with the mass conservation.