Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

The scientific report (WORD or PDF file – maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

***Proposal Title**:* Feasibility study of milimetre/terahertz low-cost graphene metasurfaces and lensing devices

Application Reference N°: 7278

1) Purpose of the visit

Aim of this visit is to characterize graphene for use in low-cost THz devices. Graphene is one-atom-thick Drude-like material with plasma frequency in THz regime, making it a very attractive platform for future millimeter/THz and optical flat-land devices (metasurfaces, planar lenses and reflectoarrrays),.Unfortunately, graphene fabrication technology is very expensive and not affordable for many research groups. Even worse, at the present state of the art, it is not clear which technological parameters of the graphene monolayer should be met to build a real-word engineering metasurface. Recently, we designed of a very low-cost (less than 2000 USD) CVD reactor for graphene synthesis, and manage to synthesize grahen samples, basic technological parameters of which are comparable to (much more expensive) commercial graphene layers. The next step is characterization of produced samples and associated patterning in order to achieve planar metasurface scattering/lensing device operating in mm/THz regime. The aim of proposed short visit is to characterize surface morphology of prodced samples with facilities and methods not available in Zagreb (scanning electron microscopy and atomic force microscopy). Furthermore, it is envisaged to test the oxygen plasma patterning as a method of graphene-based scattering/lensing device production. After the visit, subsequent electromagnetic testing od produced scattering/lensing device) will be conducted in Zagreb (in waveguide environment) Thus, the proposed visit should help in bridging the gap between physics and engineering methods needed for successful production of mm/THz graphene scattering/lensing device.

2) Description of the work carried out during the visit

Research was conducted from 29.04.2015. to 10.05.2015. instead planned 08.05.2015. to 18.05.2015. due to host research schedule. Prepared graphene samples were characterised with Raman spectroscopy on their metal substrates before and afther oxygen plasma treatment. Graphene was grown on nickel substrates by CVD process using methanol vapour. Such process provided low-cost graphene films with low defects that could be used in THz devices. Oxygen plasma etching was used to obtain geometrical patterning of graphene films.

3) Description of the main results obtained

Prepared graphene samples were characterised with Raman spectroscopy on their metal substrate before and afther oxygen plasma treatment. However, Raman spectrum of graphene lines afther treatment was not obtained. There are two possible couses: 1. Electrical field near metal substrate is equal to 0 and therefore Raman scattering is not possible so therefore Raman photon is not emitted, 2. Oxygen plasma etched complete graphene film. New masks for etching process are needed.

4) Future collaboration with host institution (if applicable)

Dr. Eva Kovacevic's group are conductioning multifrequency plasma experiment. For this purpose special matching circuit is needed to match impedance of RF generators to impedance od vacuum chamber electrodes. This circuit should also prevent RF energy flow from one generator to another and vice versa. Input impedance of such "antenna tuner" is 50 ohm and output impedance is variable due to variable plasma density in 1-2 kohm range. High output impedance results in high output voltage that can damage output variable capacitors. This circuit in not commercialy available to the best of the authors knowledge. New design is proposed for "antenna tuner" that can sustain high output voltages and can be driven by multiple RF generators. This circuit still needs to be builded and tested in variable experimental conditions.

5) Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)*

Impedance matching circuit for multifrequency RF plasma excitation (planned).

6) Other comments (if any)

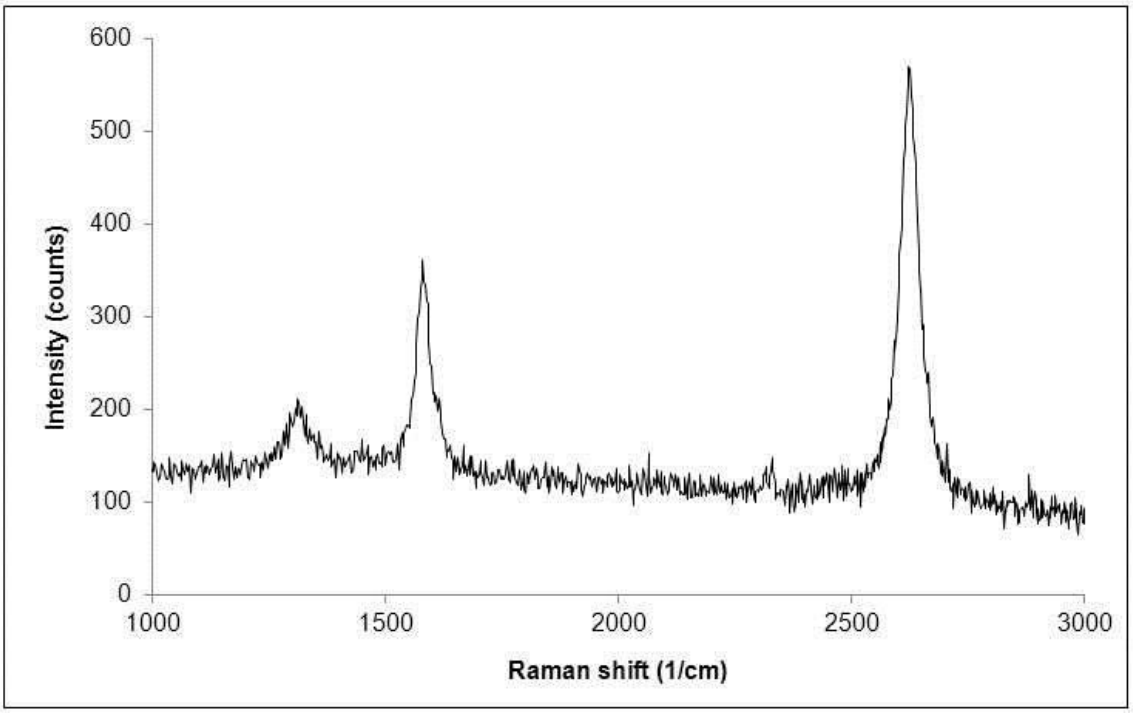

Figure 1 - Raman spectrum of graphene film before oxygen plasma ethcing. D line at 1370 cm-1 shows low concentration of defects which is desirable for THz applications. G line is situated at 1570 cm-1 and shows nice peak. 2D line at 2700 cm-1 is higher than G line and therefore this material is single or bilayer graphene.

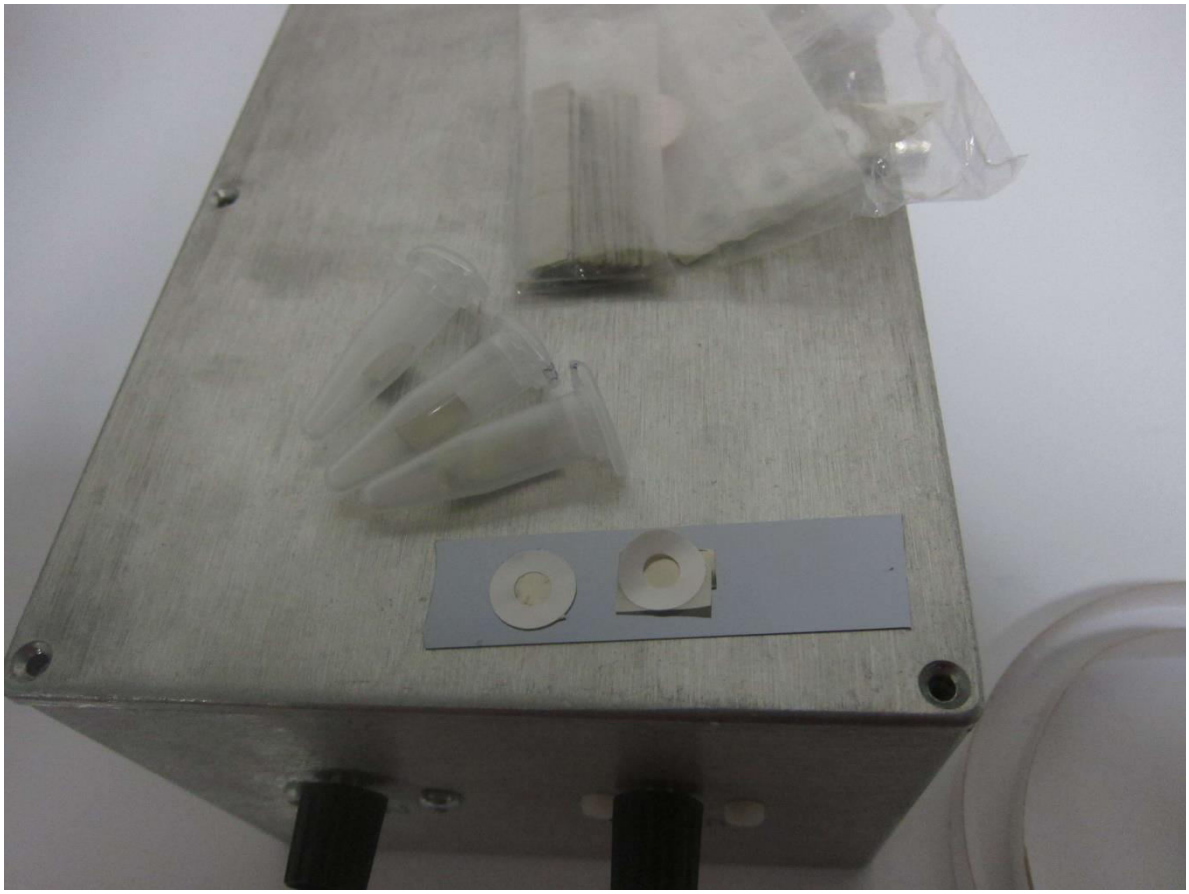

Figure 2 - Preparing graphene samples on metal substrate by attaching plastic masks. Left mask have adhesive layer for better mechanical contact between mask and graphene. Right mask is free-standing and twisted to observe etched pattern with Raman mapping. All samples are placed on silicon wafer that serves as carrying tray.

Figure 3 - Placing samples in vacuum chamber

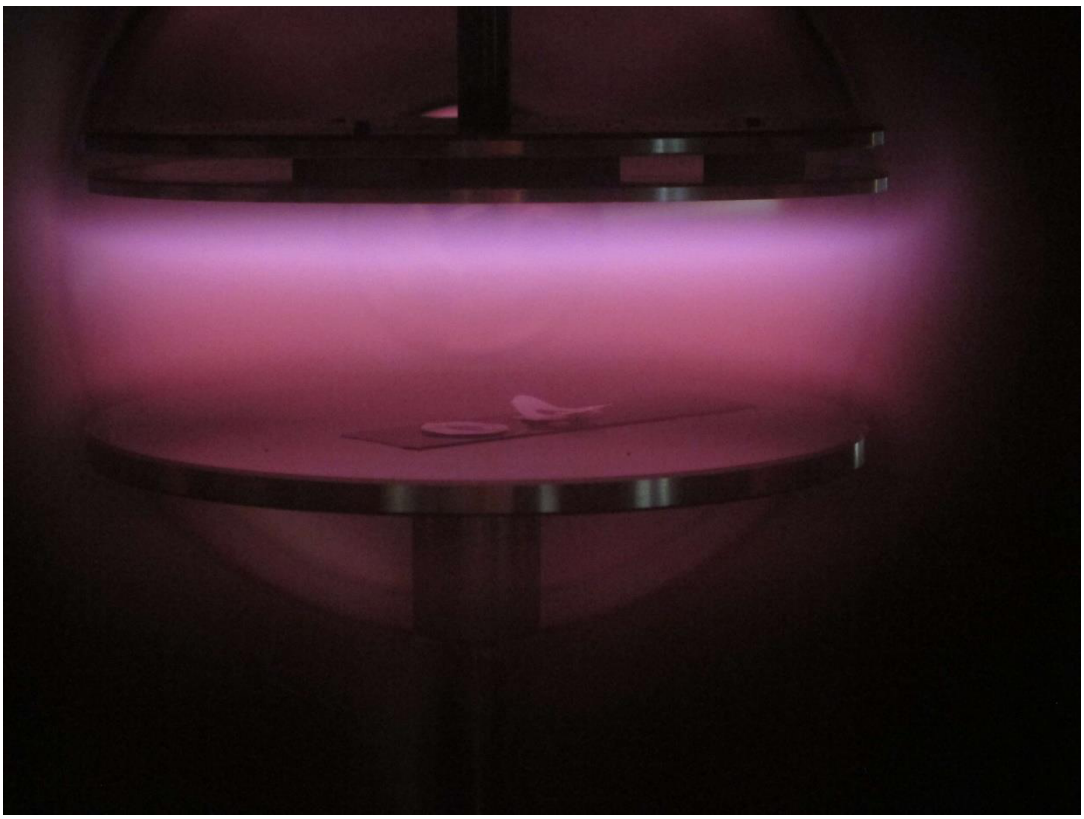

Figure 4 - Oxygen plasma etching of graphene samples. Left sample have mask attached by adhesive tape. Right is sample with free-standing mask. Pressure inside chamber is ~1 Torr, RF frequency is 13.56 MHz, RF input power is 24 W, reflected RF power is 4 W. Purple plasma colour indicates traces of nitrogen even afther 48h of pumpdown.

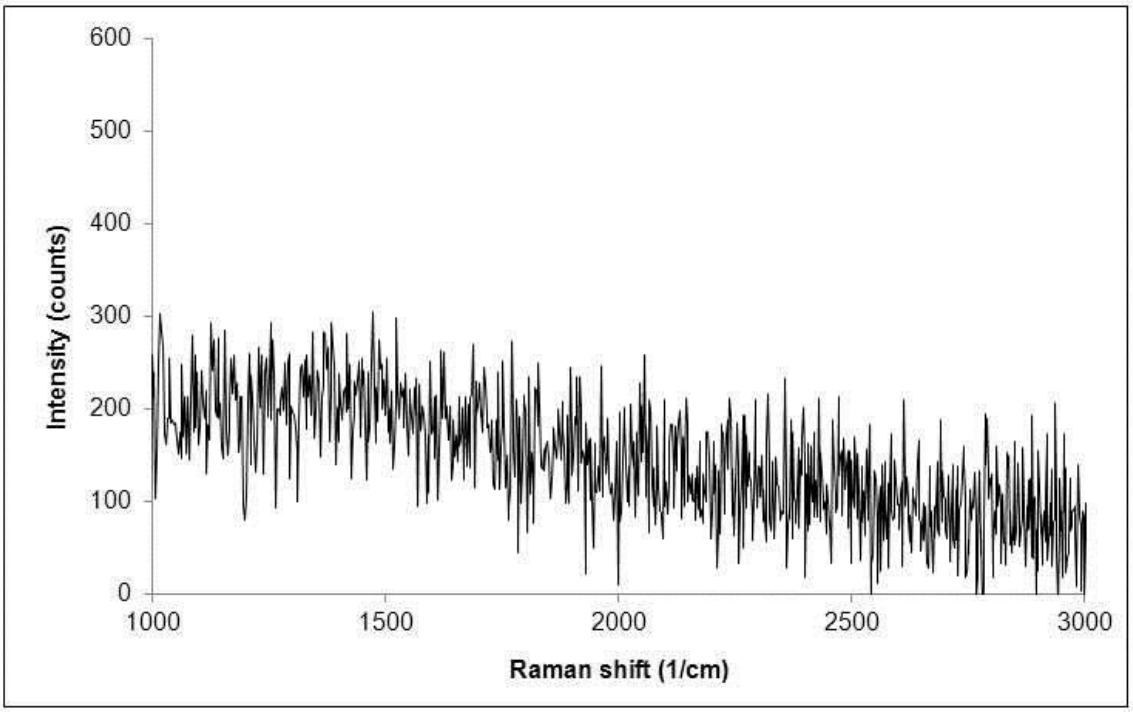

Figure 5 - Raman spectrum of samples afther oxygen plasma etching.