Diamond strip detector with laser made graphitic electrodes.

E. Alemanno [1 , 2] ,A. Caricato [1, 2] ,G. Chiodini [1], M. Corrado [1, 2], G. Fiore [1], M. Martino [1, 2], G. Maruccio [2, 3] ,A.G. Monteduro [2 , 3], P.M. Ossi [4] ,R. Perrino [1], C. Pinto [1, 2] and S. Spagnolo [1, 2].

[1]Istituto Nazionale di Fisica Nucleare, 73100 Lecce, Italy

[2]Universitá del Salento, 73100 Lecce, Italy

[3]NNL Institute Nanoscience-CNR, 73100 Lecce, Italy

[4]NEMAS Politecnico di Milano, 20133 Milano, Italy

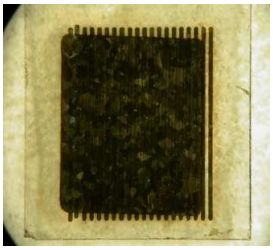

Figure 1. Optical microscopy image of the polycrystalline CVD diamond detector grade after laser treatment.

We made diamond detector (Figure 1) from a synthetic polycrystalline CVD diamond plate by irradiating its surfaces by an ArF (λ = 193 nm) excimer laser (Lambda Physik LPX305i). The diamond plate was processed in air and at room temperature [1]. Twenty micro-strip conductive layers about 70 μm each other apart and with a width of about 100 μm were realized on detector-grade diamond.

The structure and the morphology of graphite layers were created on thermal and detector grade synthetic polycrystalline CVD diamond plates, which have different optical properties.

We performed micro-Raman and photoluminescence (PL) measurements on diamond and on graphite using an Ar laser ($\lambda = 514.5$ nm) [2]. Representative micro-Raman spectra are reported in Figure 2 on the top plots. Not irradiated diamond displays a narrow peak centered at 1335 cm^{-1} and a broad G band extending from about 1450 to 1650 cm^{-1} , with a maximum around 1565 cm^{-1} . Both these features grow up from a luminescence background.

For the irradiated diamond there are D bands centered around 1360 cm^{-1} and G bands less broader and peaked at about 1590 cm^{-1} , with a shoulder at about 1630 cm^{-1}. These blue shifts are likely to be associated to the presence of a considerable fraction of disordered spa diamond. The G bands are very likely due to the presence of graphitic carbon forms in CVD diamond. A second order G band appears centered at about 2720 cm^{-1} with a single Lorentian line-shape and a FWHM of about 70 cm^{-1} which is due to a t-graphite layer. The photoluminescence (PL) spectra taken at the four selected points of irradiated diamond show a weak second order Raman G band, centered at about 2720 cm^{-1} (Figure 2 bottom plots).

For diamond thermal grade the scanning electron microscopy (SEM) show a surface homogeneously modified by the laser radiation. A randomly oriented distribution with irregularly shaped flakes, partly protruding outwards from the surface becomes evident and constitutes a signature of t-graphite with an average size estimated around 20-30 nm. For diamond detector grade the SEM micrographs show a surface morphology uniform across the whole irradiated surface with an irregular and dense distribution of nano-particles, about 200 to 400 nm in size, partly protruding outwards. From a comparison of the images about irradiated and not irradiated diamonds we can see that laser irradiation produce changes about the structure of all surfaces, but for diamond thermal grade the graphite particles are one order of magnitude smaller than the ones seen on irradiated diamond detector grade.

A method based on the transmission line model (TLM) has been employed to measure electric resistance (Figure 3 top plots). It makes use of contacts with increasing separation and by measuring the current-voltage (I-V) curve for step. The total resistance R_T is given by $R_T = 2R_C + \frac{\rho d}{wt}$ where R_C is the contact resistance, d is the distance be-

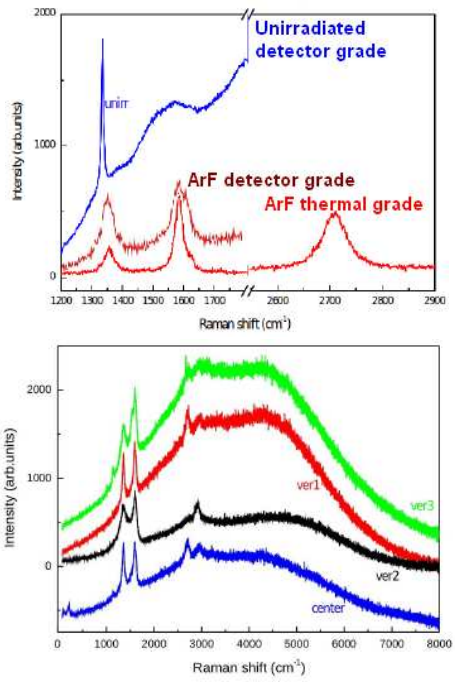

Figure 2. Micro-Raman spectra of thermal-grade a detector-grade CVD diamond samples before and after ArF laser irradiation (top plots). Photoluminescence spectra of detector-grade CVD diamond samples in four different positions after ArF laser irradiation (bottom plots).

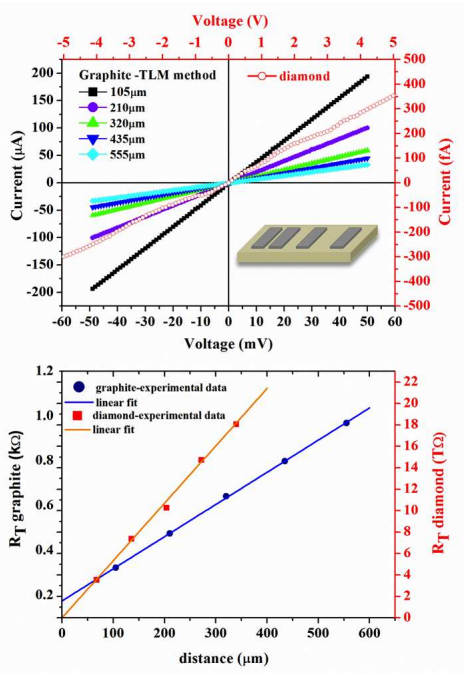

Figure 3. Top: I-V characteristics recorded on graphite micro-strip varying the contact separation distance. Inset: Sketch of the TLM test structure. Bottom: electric resistance plotted against the contact terminal distance on one graphite micro-strips (blue dots) and between different graphite (red squares).

tween the contacts, w is the width of the electrode, t is the thickness of the resistor body and ρ is the resistivity.

The contact resistance and the resistivity of the material under investigation can be then evaluated by means of a linear fit of the experimental data. A good linearity of resistance dependence on contact separations was always found, confirming a reproducible graphitization process. From the statistical analysis conducted on the experimental data, we obtained a mean value of the slope of the linear fits of $1.44\text{x}10^6\Omega/m^2$ (Figure 3 bottom blu plot). Since the contact width, w, is 100 μm (measured by SEM) and assuming that the thickness of the graphite micro-strip is about 60 nm on the base of the laser fluence of about 3J/cm^2, we get a resistivity value ρ_c of about $8.6\text{x}10^6\Omega\text{m}$ in good agreement with tabulated values for graphite.

We also evaluated the diamond resistivity ρ_D by TLM performed keeping fixed the first contact on a graphite strip and changing the position of the second contact on the subsequent graphite electrodes. From the slope of the fit we obtaining a value around $6\text{x}10^{10}\Omega\text{m}$ which is slightly smaller than the values reported by using normal top and bottom electrodes (Figure 3 bottom red plot).

This work pave the way to the realization of position sensitive nuclear detector entirely made by carbon atoms. Work is in progress to fully characterize the diamond micro-strip detector in terms of efficiency and space resolution.

REFERENCES

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