Laser Lithography for Production of Diamond Detectors

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Laser lithography system

Diamond detectors are usually produced from the electronic (detector) grade diamond material in a form of thin plate or film. In order to produce diamond detector, the plate has to be equipped with suitable (most often metallic) electrodes. Such metallic electrodes were - and still are - produced at GSI Target Laboratory by sputtering of one or more thin metal layers on the surface of the diamond. A particular electrode structure in that case is obtained by using stencil masks that are also a limiting factor since the minimal obtainable structure is of about 100 μm. To overcome this limitation the laser lithography system (shown in Fig. 1) was acquired and put into the operation in the GSI Detector Laboratory.

Figure 1: Lithography room in the clean room area of the Detector Laboratory. Working table with the spin coater and the hotplate (left in the photo), and the laser pattern generator with control computer (right).

The lithography system consists of *Ramgraber* M150 spin coater, *Ramgraber* M-HP150 hotplate, and the laser pattern generator *Heidelberg Instruments* μPG 101. The first two devices are suitable for processing of wafers up to 6$''$ with wide variety of photoresist coatings. The μPG 101 is equipped with a solid state (diode) laser of 405 nm wavelength with maximum output power 100 mW. With present configuration the maximal writing area of 90 x 90 mm^2 can be processed with the minimal resolution of 1 μm. During 2013 the system was successfully commissioned and the first diamond detectors were produced and tested.

Diamond detector production

In contrast to common photo-lithography where photomasks are used to expose photoresist, in laser lithography the laser pattern generator is used to directly expose photoresist. In processing of diamond detectors two approaches are possible: in the lift-off process the photoresist coating is removed from the part of surface which needs to be metalized (*i.e.* occupied by the final electrode) and then after sputtering of the metallic layer over the whole diamond the remaining photoresist is "lifted-off" from the surface leaving the metallic electrode only in the previously photoresist-free area. In the other approach the metalization of the whole surface is made at first followed by photoresist coating and exposure. After developing and partial removal of the photoresist, the exposed (unprotected) metallic surface is etched until metallic layer is removed. After removal of remaining photo-resist the electrode is ready for further fabrication.

While the first approach is simpler in implementation since it does not require aggressive chemical treatment (etching), the latter is preferred in production of diamond detectors because it allows better diamond surface preparation for the metalization of electrodes.

An additional obstacle in processing of the diamond detectors is their shape and size; the typical surface of a single-crystal diamond is usually less than 5x5 mm^2 which presents challenge for spin-coating in cases where electrodes are up to the edge. As it can be seen from Fig. 2, during the spin coating of rectangular substrates the buildup of the photoresist beads in corners cannot be avoided. While such obstacle would be difficult to treat by the conventional photo-lithography, by recurrent exposure of the photoresist in corners we can produce desired electrode shape.

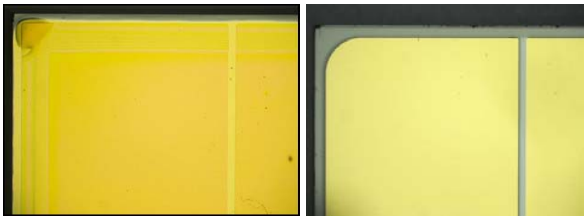

Figure 2: HADES diamond detectors prepared with the Cr+Au metalization, electrodes are processed with the laser lithography. Left: the corner of the diamond plate with the photoresist bead buildup, right: the electrode after etching and the photoresist removal. The feature size (gap between the electrodes) is 80 μm.

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