Electron Beam Lithography of Antidot Arrays for the Fabrication of Nanogenerators and Detectors in 2DEG Materials

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Microwave radiation induced photovoltage in two-dimensional electron gas (2DEG) holds promise for producing a system which can support carrier transport without the need for an externally applied voltage.[1] Such systems typically produce photovoltages in the nanovolt range, however it has been demonstrated that it is possible to enhance the photovoltage effect by breaking the spatial inversion symmetry of the 2DEG material by using an array of asymmetric antidots.[2-3] This antidot array enables a ratchet effect to take place when the sample is irradiated with microwaves enhancing the photovoltaic effect.

The 2DEG material at the interface of our Si/SiGe heterostructure (See Figure 1) exhibits the capability of directed transport when irradiated with microwaves. By patterning an array of semicircular antidots and etching them into the Si/SiGe device we are able to produce photovoltages in the millivolt range. The asymmetric semicircles act as scatterers preferentially directing carriers to one side of the device inducing a potential difference. These photovoltaic devices have great potential for use as microwave detectors, nanogenerators, and other wireless communication devices.

Electron Beam Lithography was used to pattern the semicircular in positive tone ZEP 520 resist. The patterned resist is then used as a soft mask to transfer the antidot array via an Inductively Coupled Plasma (ICP) etch into the Si/SiGe heterostructure (See Figure 2). AFM and SEM metrology are performed to ensure pattern size and etch depth are accurate. Once patterned the samples are tested at the CNRS in Grenoble France. The samples are subject to magnetotransport measurements to determine electron transport properties. Photovoltage measurements are carried out while irradiating the samples with microwaves (See Figure 3), these measurements are performed in a 2 point configuration measuring the potential difference across the hall bar structure induced by the microwave radiation.

1. *J. Liu, M. A. Pennington and N. Giordano, Phys Rev B* ***45*** *(3), 1267-1272 (1992).*
2. *A. D. Chepelianskii and D. L. Shepelyansky, Phys Rev B* ***71*** *(5) (2005).*
3. *S. Sassine, Y. Krupko, J. C. Portal, Z. D. Kvon, R. Murali, K. P. Martin, G. Hill and A. D. Wieck, Phys Rev B* ***78*** *(4) (2008).*
4. *I. Bisotto, E. S. Kannan, S. Sassine, R. Murali, T. J. Beck, L. Jalabert and J. C. Portal, Nanotechnology* ***22*** *(24) (2011)*

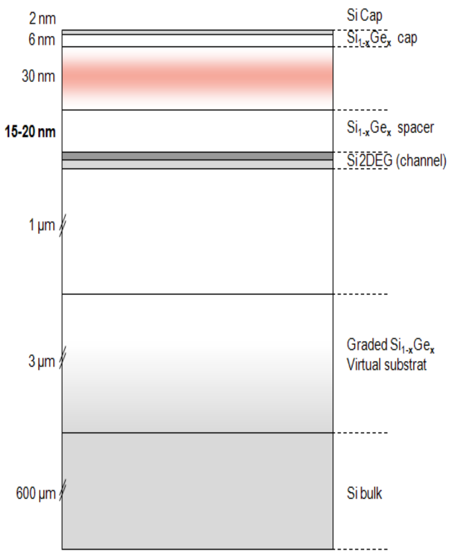

Figure 1: Material Stack of Si/SiGe heterostructure. The antidot pattern is etched into the Si/SiGe spacer region right above the Si 2DEG material inducing scattering mechanisms for the ratchet effect to take place.

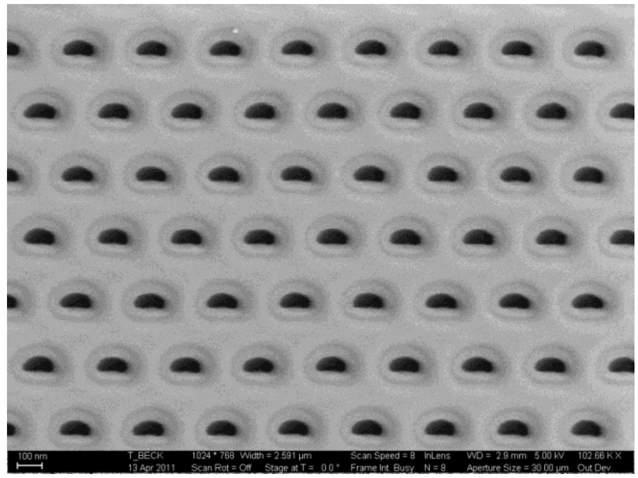

Figure 2: SEM image of 60 nm radius semicircular array of antidots etched into the Si/SiGe heterostructure.

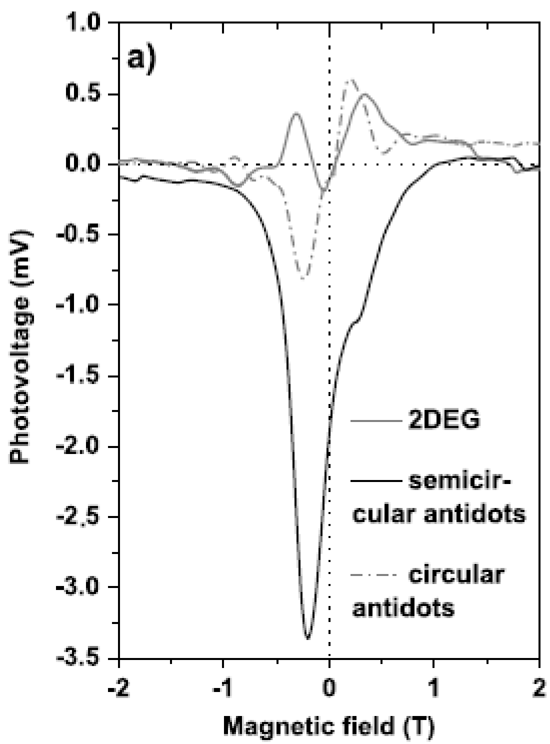

Figure 3: Plot of photovoltage comparing semicircular and circular antidots as well as the 2DEG material without any microwave radiation. [4]