ESRF	**Experiment title:** Wired Quantum Dots	**Experiment number**: HC-1711
Beamline: ID16B	**Date of experiment**: from: 12 Feb 2015 to: 17 Feb 2015	**Date of report**: 20. July 2015
Shifts: 15	**Local contact(s)**: Dr. Damien Salomon / Dr. Gema Martinez-Criado	*Received at ESRF:*

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Report:

The “wired quantum dots” were realized by irradiating Si nanowires with high fluencies of As^+ and Ga^+ and subsequently annealing the samples with an intense flash lamp. This typically forms a Si-Ga-GaAs-Si hetero-nanowire. If contacted at both ends, these nanowires form a Schottky diode device, which emits visible, room temperature electro-luminescence (EL) when reverse biased. Several of these devices were investigated by XRF at ID-16B, while also measuring the current through the biased device with an amplifier. This produces a signal similar to the more common Electron Beam Induced Current (EBIC), namely X-ray Beam Induced Current (XBIC), which can be correlated to the XRF maps.

Figure 1a) shows a typical SEM image of one investigated device. The overlay of the XRF maps and XBIC signal shows that the electrically active region is found at the Ga-GaAs interface (Figure 1b). This is clearly confirmed by the plot of the nanowire of the XRF and XBIC signals extracted from the maps along the nanowire (Figure 1c).

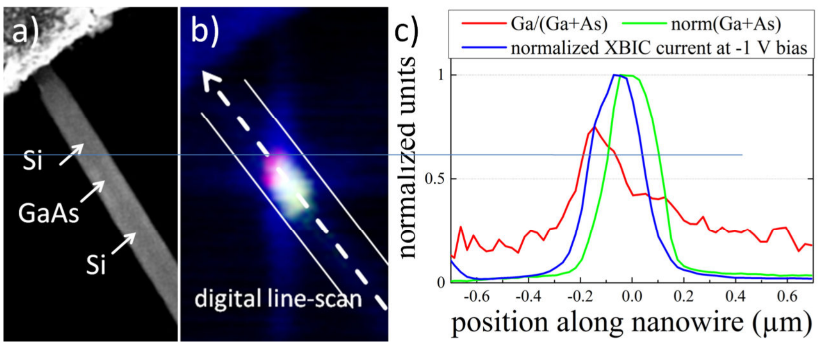

Figure 1: a) SEM image of a contacted Si-GaAs hetero-nano-wire. b) Overlay of the concentration maps of Ga/(Ga+As) and (Ga+As) with the XBIC signal and c) plot of these to a normalized scale.

Because high-fluence ion irradiation is required for the synthesis of the Si-GaAs hetero-nanowires, a part of the alocated beam time was also used to investigate the fundamental ion beam-nanostructure interaction. Due to the enhanced sputtering in nanowires, the incorporation of dopants in nanowires does not increase linearly with the irradiated ion fluence. To investigate this effect, the Mn-Zn ratio in several ZnO nanowires irradiated with 0.25, 0.5, 1 and 2×10^{17} cm^{-2} of 175 keV Mn^+ was determined by high-resolution XRF (Figure 2).

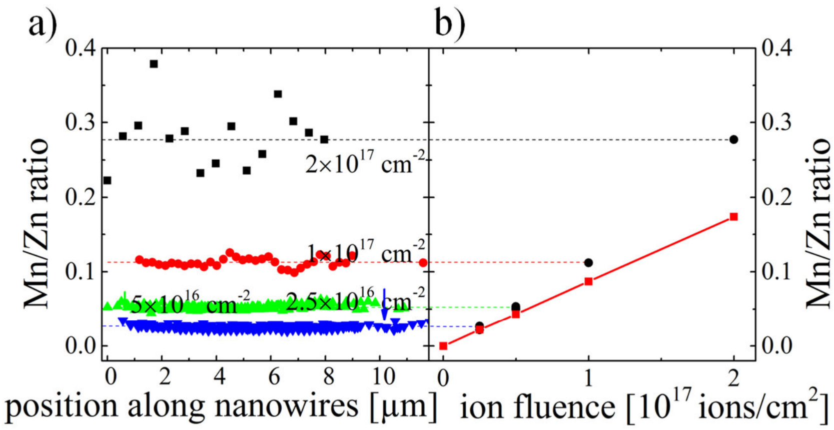

Figure 2: a) Mn-Zn ratio along the nanowire length for sparse nanowire samples irradiated with the indicated ion fluence of 175 keV Mn^+. There is no concentration gradient along the nanowire length. In b) the average ratio obtained for the respective ion fluence is shown in black next to the simulation without sputtering in red (from [2]) .

Compared to previous experiments (experiment HC-871 and [1]), these nanowire samples were more sparesely distributed and upstanding on the irradiation substrate, rotated during the irradiation, and individually investigated by SEM before and after the irradiation. With these careful preperations, the XRF results confirm that the dopant incorporation is homogeneous along the nanowire length and increases super linearly with the ion fluence due to sputtering of the nanowire material.

Table 1: Number of samples characterized

XBIC	XRF
9 contacted Si-Ga-GaAs-Si hetero-nanowires	14 individual ZnO:Mn nanowires

In summary, we obtained further excellent results, which are briefly summarized here and either published in the cited reference or being prepared for publication:

- Elemental quantification:
  - the Si sections in Si-Ga-GaAs-Si hetero-nanowires contain a high percentage of As,
  - the GaAs nanocluster contains some Si,
  - a Ga layer to one side of the GaAs nanocluster is confirmed,
  - sputtering greatly influences the incorporation of dopants in nanowires.
- XBIC:
  - the XBIC signal originates at the Ga-GaAs interface.

Additionally, the following manuscript has been published on our obtained XRF results targeting also “wired quantum dots”.

[1] Enhanced sputtering and incorporation of Mn in implanted GaAs and ZnO nanowires. Johannes A, Noack S, Paschoal W, Kumar S, Jacobsson D, Pettersson H, et al. *Journal of Physics D-Applied Physics.* **47** (39) 394003 (2014).