

**Experiment title:**XRF and XANES characterization of high p-doped Si_xGe_{1-x} nanowires**Experiment number:**

MA-4642

Beamline:

ID16B

Date of experiment:

from: 18/09/2020 to: 20/09/2020

Date of report:

21/01/2021

Shifts:

9

Local contact(s):

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*Received at ESRF:***Names and affiliations of applicants (* indicates experimentalists):**

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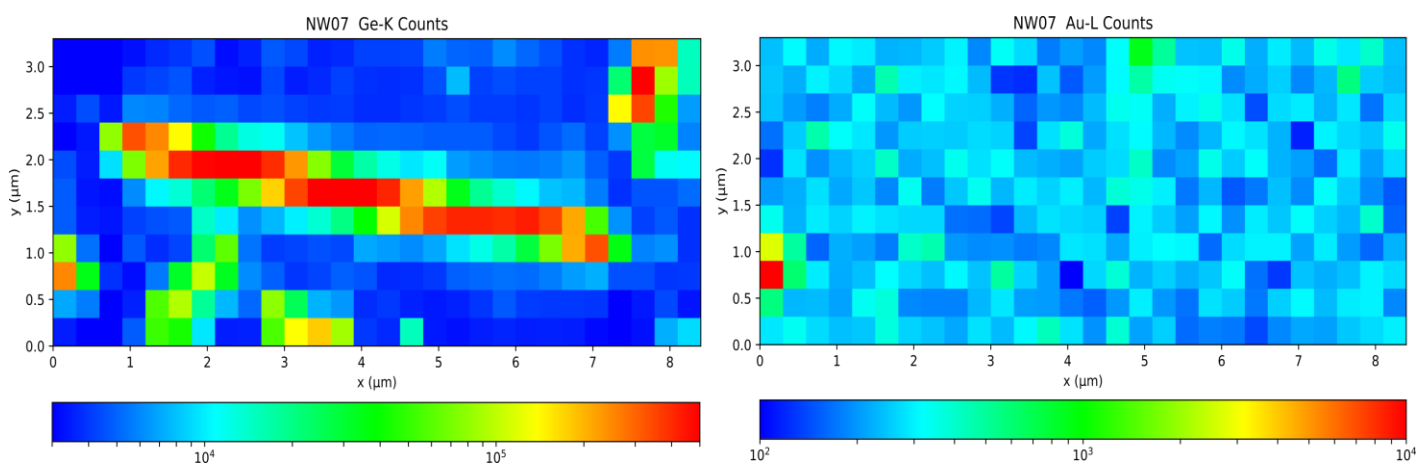
Report:

This proposal was partially allocated (only XRF experiments). During the 9 shifts, several SiGe NWs from 4 different samples were dispersed on Kapton foils from 4 samples and characterized by XRF in order to elucidate the mechanism behind the Au-incorporation into the NWs during their growth, and the best growth conditions to avoid this effect. Table 1 summarizes the samples characterized during this experiment and their main characteristics.

<i>Samples</i>	<i>SiH₄:B₂H₆ ratio</i>	<i>Composition</i>	<i>HCl:Si ratio</i>	<i>Au inclusion in NW lattice</i>
S1 (G670)	550	Si _{0.63} Ge _{0.37}	1.75	No
S2 (G665)	470	Si _{0.59} Ge _{0.40}	1.75	Surface
S3 (G673)	410	Si _{0.68} Ge _{0.31}	1.75	No
S4 (G677)	365	Si _{0.60} Ge _{0.30}	1.75	Yes

Table 1. List of samples proposed to be measured. All NWs are growth under the same conditions except for the SiH₄/B₂H₆ ratio. The other growth conditions are: 180 min of growth time at 650 °C and 2.5 torr. Si:Ge ratio of 25.

Two representative XRF maps are displayed in the Figure 1. It can be observed that the Nws grown with low diborane concentration do not show a measurable Au concentration aside of the NP at the tip(used as catalyst of the growth). On the other hand, high diborane concentrations during growth conditions lead to the progressive inclusion of gold along the NW.



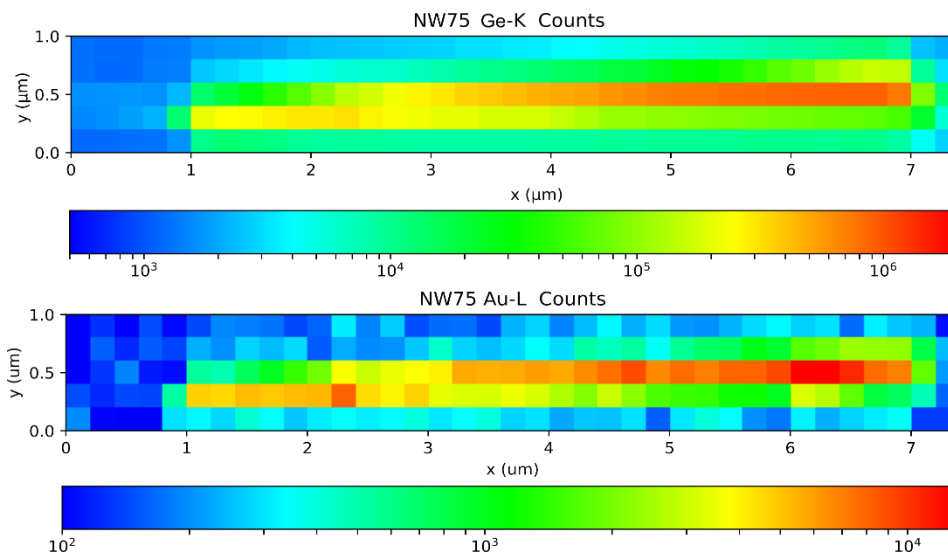


Figure 2. XRF maps of two NWs showing the Ge and Au distribution along the entire nanostructure. The pattern observed in the sample 1 (top) compared with the flat distribution observed in sample 4 (bottom) is considered to be produced by the high content of diborane in the growth process.

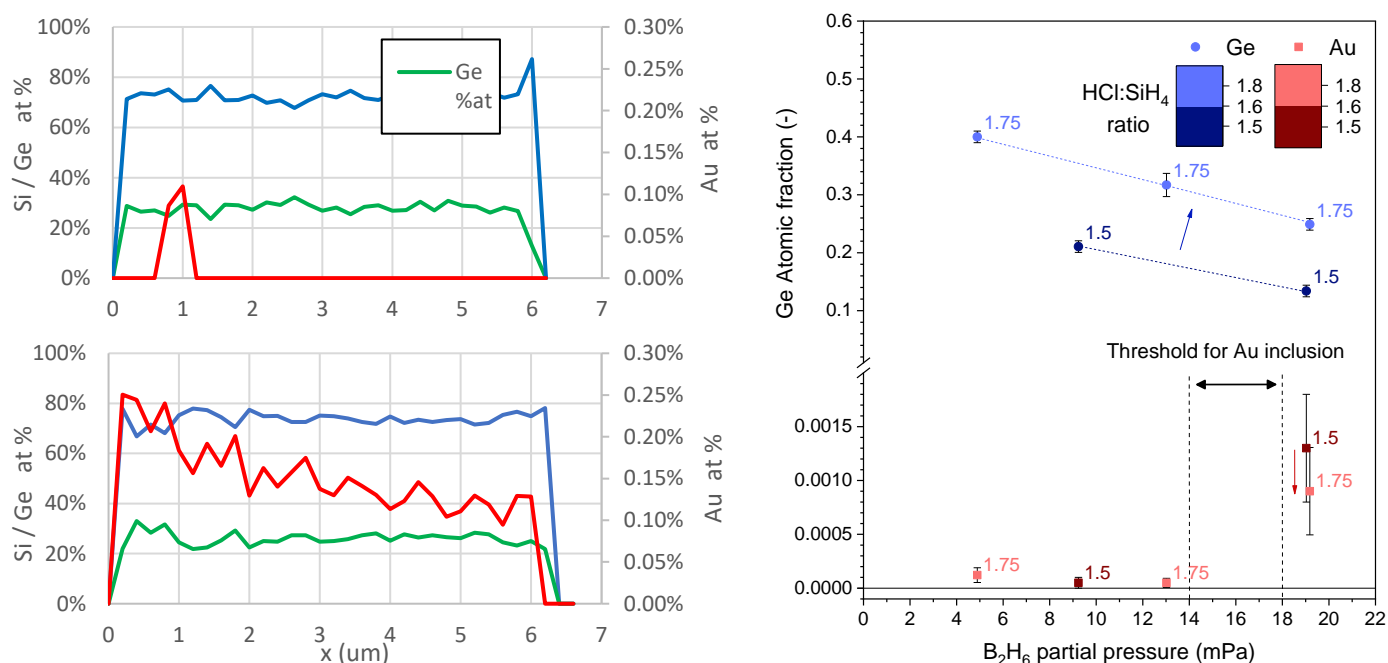


Figure 2. Calculated concentration profiles extracted from the XRF maps. Sample 1(top) clearly shows the absence of Au except at the tip, where the catalyst Au NP is located, whereas sample 4 (bottom) shows a notorious increase in the Au concentration along the NW. Right chart shows the summary of all concentration results of the study.

Figure 2 shows the longitudinal concentration profiles obtained for 2 representative NW studied (samples 1 and 4). The concentration trends can be observed in the rightmost chart. Results from the previous in-house measurements were included as well (HCl:Si ratios of 1.5) in order to further assess the effect of HCl as an effective agent for Au inclusion suppression. However, Sample 2 measurements were not yet included in the study because later SEM analysis showed superficial NP. Beamtime is still necessary to perform the initially proposed nano-XRD and nano-XANES experiments to further assess whether this detected gold is superficial or included into the NW lattice. The latter would modify the electronic structure of the crystal. Moreover, the HCl effect will be further studied using samples with higher HCl:Si ratios.