ESRF	**Experiment title:** Standing waves of highly dilute Fe dopants in semi-insulating InP	**Experiment number:** SI 266
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Report:

High resistivity, semi-insulating (SI) InP and InGaAsP alloys lattice matched to InP are of great importance in integrated opto-electronic devices for electric insulation between different functional areas and for high-speed applications where low capacitance is needed. For example, SI InP has been used as blocking layer in InGaAsP buried heterostructure layers and as a base or insulating gate in field effect transistors.

SI (resistivity $> 10^7\ \Omega$ cm) InP is usually obtained by intentionally doping with Fe; Fe acts as a deep acceptor which compensates Si and S shallow donors present as impurity atoms. The active level is Fe^{3+}/Fe^{2+}, located 0.49 eV below the conduction band edge.

In Fe-doped SI InP it is found that the resistivity increases with Fe concentration up to a certain value, roughly 10^{17}-10^{18} atoms/cm^3, where a plateau is reached. Further increases in the Fe concentration lead to a drastic decrease in the resistivity. It is generally believed that the Fe acceptor atoms are substitutional, in In sites. FeP clusters have been detected by TEM at high concentrations ($> 5\ 10^{18}$ atoms/cm^3) and their presence has been naturally linked to the decrease in resistivity at high concentrations.

However, no direct structural investigation of the Fe site has been reported. Undoubtedly this is due to the extremely low atomic concentration which make conventional methods impossible.

In order to gain direct structural insight in the position of Fe dopants in SI InP we have performed XSW measurements on a set of samples deposited by Chemical Beam Epitaxy in the CSELT laboratories in Turin, Italy. XSW measurements were performed on the ID32 beamline. The difficulty in the measurements lies both in the extremely low concentration of the samples and in the fact that Fe is present in many parts of the experimental apparatus.

In the figure below we show the XSW measurements for four samples: the Fe K_α fluorescence intensity is plotted as a function of angle around the (004) reflection of InP, which serves as an angular reference.

While quantitative data analysis is in progress some preliminary conclusions can be drawn. It is clear that significant changes occur in the lineshape above 5 x 10^{18} atoms/cm^3. Specifically, for the three lowest concentration samples the lineshape is typical of a substitutional impurity in InP samples. This indicates that at low concentrations Fe is substitutional in InP. The lineshape for the sample with 10^{20} Fe atoms/cm3 has a more complex lineshape. The split peak in the fluorescence is linked to the presence of two peaks in the reflectivity (not shown), most probably due the precipitation of Fe-rich clusters; the total modulation is smaller than in the lower concentration samples, indicating a lower coherent fraction as the Fe atoms loose registry with the InP lattice.