Summary of Doctoral Thesis

Title of Doctoral Thesis: Growth of iron-silicide nanofilms with boundary-less and three-dimensional shape properties on Si substrates

Name: Irmikimov Aydar

Summary of Doctoral Thesis:

In this study, I can address two main point of interest.

Firstly, at second chapter I have revealed the growth process from Fe nanofilm deposited on Si(001) substrate to β-$FeSi_2$ perfect crystalline nanofilm without step boundary defects in heating process, analyzing the snapshots of cross-sectional TEM atomic images of the samples during the process. The key phase transition source in the case of boundary-less nanofilms was discovered to be the step boundary between the substrate and the deposited layers, which is critical for the generation of this unique structure with no boundary defects.

Secondly, in the third chapter, I made s3D Si pyramids with atomically flat Si{111} facet surfaces on Si(001) substrates and demonstrated that the fabrication of epitaxially grown thin films in the same way as standard planar substrates. Preparation of the substrate and treatment processes, such as a combination of wet and dry etching in the proper proportions for the desired size of the 3D structure, are the top priorities in creating high-quality 3D structures. It is possible to produce 3D structures suitable for a wide range of applications by combining a variety of treatment combinations. The methods utilized in this study of a 3D atomically architected structure have proved the realization of programmable material development in any direction supported by the 3D structure surfaces. This discovery opens up new avenues for developing geometrically induced functions in solid nanomaterials.

In terms of future applications, both of the thesis's subjects are highly useful. β-$FeSi_2$ nanofilm is ideal for optoelectronic device and/or thermoelectric applications due to its consistency. A novel method for creating high-quality 3D surfaces has been developed, paving the path for future experimentation with boundary-less nanofilms and customized 3D substrates to develop new functional devices.

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Summary of Thesis Examination Results:

This study includes two related research works. Firstly, It is revealed that the growth process from Fe nanofilm deposited on Si(001) substrate to β-$FeSi_2$ perfect crystalline nanofilm without step boundary defects in the heating process, analyzing the snapshots of cross-sectional TEM atomic images of the samples during the process. The key phase transition source in the case of boundary-less nanofilms was discovered to be the step boundary between the substrate and the deposited layers. Secondly, 3D Si pyramids with atomically flat Si{111} facet surfaces on Si(001) substrates were created and demonstrated the fabrication of epitaxially grown thin films, in the same way as standard planar substrates. Preparation of the substrate and treatment processes, such as a combination of wet and dry etching, are important in creating the desired size of the 3D structures. The methods utilized in this study of a 3D atomically architected structure have proved the realization of programmable material development in any direction supported by the 3D structure surfaces. This discovery opens up new avenues for developing geometrically induced functions in solid nanomaterials.

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As described above this thesis has revealed β-$FeSi_2$ perfect crystalline nanofilm without step boundary defect and a 3D pyramid out of epitaxially grown iron silicide is created. Because this knowledge is fundamentally important to the basic surface science of semiconductors, the committee agreed that this thesis is worth as a Ph.D. thesis for a Doctor of Engineering.