Electrochemical Nanopatterning Based on Mechanical Generation of Surface Defects in Semiconductors

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I. INTRODUCTION

The aim of the work is the investigation of nanoscale selective electrochemical etching on mechanically induced defects on semiconductor surfaces. The nanometer size grooves were produced by sensitizing semiconductor surfaces (Indium Phosphide and Silicon) with a mechanical contact patterning technique, i.e. nanoscratching at low loading forces at the threshold between elastic and plastic contacts. Subsequently site-selective electrochemical dissolution was triggered in a HCl and HF electrolyte.

II. RESULTS

A. Selective dissolution into pre-scratched InP

The work on InP reveals that for optimized forces, highly confined dissolution in well-defined channels of 125 nm width can be obtained as visible in Fig. 1. Transmission Electron Microscopy (TEM) cross sectional analysis of the scratches before and after electrochemical experiments shows that the dislocations generated are confined in a well-defined volume below the surface and that exactly this dislocated volume is dissolved. The site selective activation is ascribed to these surface dislocations [1]. Based on contact mechanics, the lateral resolution and the morphology of the dissolved groove can be explained by the dissolution time and the tip radius and the morphology by the applied load. The threshold to generate the first dislocations is analyzed, and one shows that the load threshold to generate the first dislocation is twice lower in scratching than in indentation. By modeling the mechanical stress fields using the Hertz's theory, this behavior is found to be related, during scratching, to the friction between the surface and the tip [2]. Moreover, the Hertz's model proposes that dislocations nucleate firstly at the surface and then propagate inside the bulk. The dislocation nucleation process explains the Pop-in event which is characterized by a sudden extension of the indenter inside the surface during loading. Finally, one proves that the nanoscratching technique is a suitable method to control dislocation nucleation inside a crystalline material.

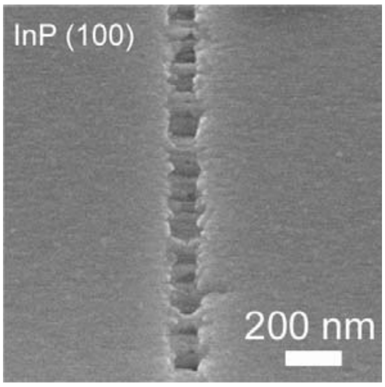

Fig. 1 *SEM micrographs of a 50 µN scratched InP surface after electrochemical etching in 1M HCl electrolyte.*

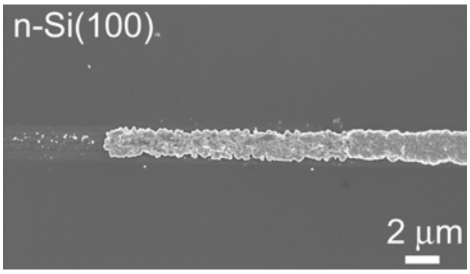

Fig. 2 *Copper wire electrochemical deposited on a pre-etched into HF scratched silicon semiconductor. Highly selectivity is obtained into the scratch area.*

B. Copper deposition into pre-etched scratched silicon

The principle of dislocations dissolution has been extended to silicon. Nanoscratches were realized at the limits between elastic and plastic contact. TEM and Raman investigation of the microstructure show that high pressure field under the tip during scratching induced dislocations in the bulk and phase transformation at the surface of the groove. First results on dissolution in hydrofluoric acid (HF) electrolyte followed by a copper metal electrochemical deposition show that very high selective electrochemical copper wire can be produced on a pre-etched defective surface into HF as visible in Fig. 2 [3].

III. CONCLUSION

This works that links together contact mechanics and electrochemistry can be used to directly produce well defined porous nanometer sizes trenches and metal nanowires on semiconductors without requiring any classical UV masking techniques.

IV. REFERENCES

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