FORMATION OF "BLACK SILICON" BY LASER RADIATION FOR SOLAR CELLS APPLICATION

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Abstract

The possibility to form "black silicon" on the surface of Si structure by Nd:YAG laser radiation has been shown. The shape and height of micro-cone structure strongly depends on Nd:YAG laser intensity and number of laser pulses. Si micro-cone structure spectral thermal radiation is close to black body spectral radiance, which makes this structure useful for solar cells application.

Key words: *Black silicon, laser processing, black body radiation.*

Introduction

"Black silicon" [1] is a novel type of material, which can absorb incident sun light by approximately 98%, generating more current than ordinary Si (60%). Usually "black silicon" consists of needle like spikes. If a light is shone on such a surface, it repeatedly bounces back and forth between the spikes in a way that most of it never comes back out again [1].
Black Si" is an excellent material for solar cells. It absorbs light more effectively, generating hundreds times more current than conventional Si [1]. Besides, this material could also be used to make infrared detectors, a new application for Si. The aim of the study is to elaborate a new controllable method of "black Si" formation on a Si wafer by Nd:YAG laser radiation.

Experimental part

For experiments we selected p-type Si samples. After Si samples irradiation by focused Nd:YAG laser beam with following parameters: pulse duration τ=150 μs, wavelength λ=1064 nm, intensity I=4 MW/cm^2, the "black silicon" was formed. In figure 1 scanning electron microscope (SEM) study of the irradiated surface has shown formation of microcones after Si where irradiation by laser at intensity 4 MW/cm^2.

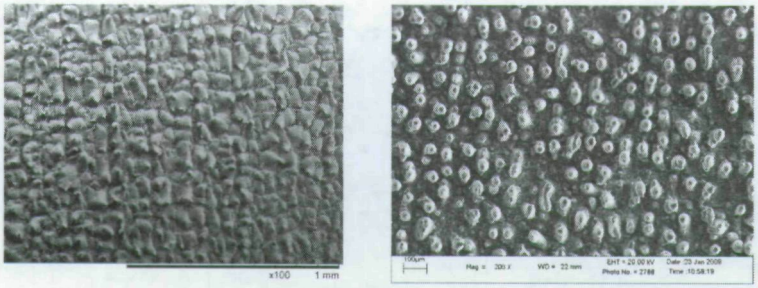

Fig. 1. SEM image of Si (left) and Si/Ni (right) surface irradiated by Nd:YAG laser

Microcones diameter at half height can vary from 10 μm up to 40 μm and height can reach up to 100 μm. The advantage of Ni/Si structure comparison with Si samples is that Ni/Si samples has electric contact on top of microcones, which was approved by SEM measurements with chemical analysis module. Those contacts can be used in applications such as solar cells or infrared detectors. The control of micro-cone shape and height was achieved by changing the laser intensity and number of pulses. Number of pulses has much more effect on micro-cone height than laser intensity.

Comparison to our previous research with Si/Ni [2], micro-cones formed on the surface of Si are not as regular as it is with Si/Ni structure.

In addition, we have made spectral thermal radiation measurements for irradiated and non irradiated areas of Si sample. Our results showed that micro-cone structure formed by laser radiation at intensity I=4 MW/cm^2 has the closest spectral thermal radiation to "black body" in same part of spectrum comparison with non irradiated, see figure 2. It means Si microcones absorb more indecent sunlight than conventional Si.

Conclusion

1. The possibility to form "black silicon" on the surface of Si and Ni/Si structure by Nd:YAG laser radiation has been shown.
2. The shape and height of micro-cone structure strongly depends on Nd:YAG laser intensity and number of laser pulses.
3. Micro-cone structure spectral thermal radiation is close to "black body".

References

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