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The evolution of defect formation during the deposition of thin layers of ZnO on the surface of hierarchical porous silicon and subsequent multi-stage annealing

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INTRODUCTION & AIM

Nowadays the range of applications of sensor technologies is continuously expanding. Their use in biology and medicine, where sensitivity requirements are increased, is becoming relevant. It is known that the sensor response depends on the level of ordering of the particles of matter. If the structure is regular and the level of fractality is high, the exciting signal moves along the surface of the sample by a short trajectory at a given speed. It is interesting to study the sensory characteristics of a material with several levels of hierarchy and various fractal parameters.

The Pb paramagnetic center is one of the main causes of degradation of silicon semiconductor devices. Methods with increased accuracy are needed to detect such particles. This is due to the low concentration, the variety of the hyperfine structure of the environment and, in some cases, the diamagnetic environment of the center. However, when a porous, hierarchical surface is obtained, the concentration of Pb centers increases significantly.

The aim of the research is the determination of the properties of one-dimensional zinc oxide nanostructures by measuring EPR spectra with a sequential change of microwave power.

METHOD

The examination and analysis of micro- and nanoparticles on the surface of the samples was conducted by scanning electron microscope (SEM) (JSM-6490LA ("JEOL", Akishima, Japan). The take-off angle for the JSM-6490LA is 35°, with an analytical working distance of 10 mm. The microscope has a high resolution of 3.0 nm.

EPR spectrometer "JEOL" (JES-FA200, Akishima, Japan). Measurements in the ranges ~9.4 GHz (X-Band) and ~35 GHz (Q-Band). Microwave frequency stability ~ 10−6. Sensitivity—7 × 109/10^{-4} Tl. Resolution—2.35 μT. Output power—from 200 mW to 0.1 μW, quality factor (Q-factor) 18,000.

RESULTS & DISCUSSION

The SEM images show a developed surface structure with nanoscale rods, at the ends of which zinc oxide crystallites are formed. Flower-like structures are synthesized by combining rods and enlarging crystals. An interesting question is the energy stability of the formed structures (Fig 1).

Regular, narrow lines were detected in the EPR spectra of the sample (Fig 3). This corresponds to signals from a limited number of paramagnetic particles uniformly distributed in the volume of matter. The properties of this spectrum do not change over a wide range of microwave power. Consequently, the formed nanostructures are energetically stable.

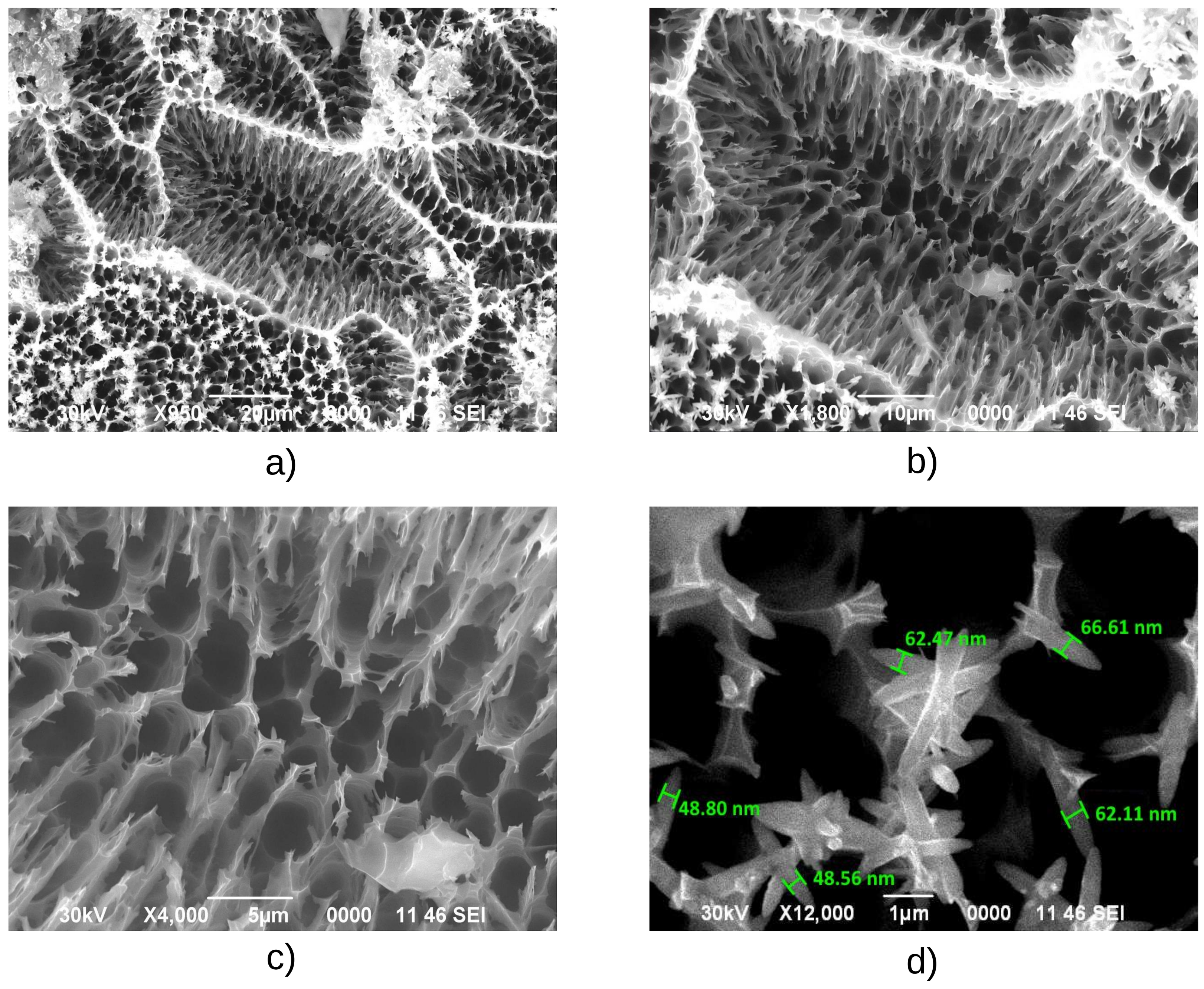

Figure 1. SEM images at various scales: a- 20 μm, b- 10 μm, c- 5 μm, d-1 μm

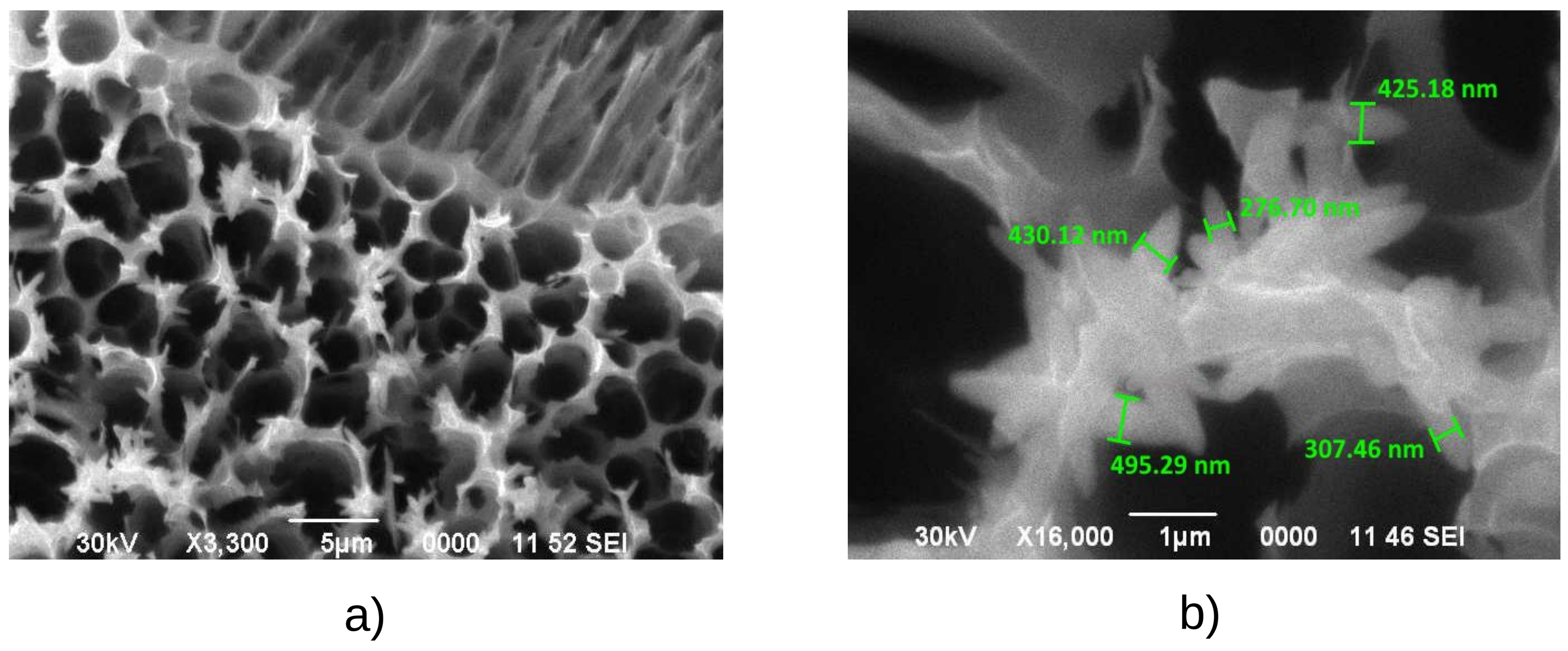

Figure 2. SEM images for the sample after annealing at 200 ^{0}C in the air atmosphere

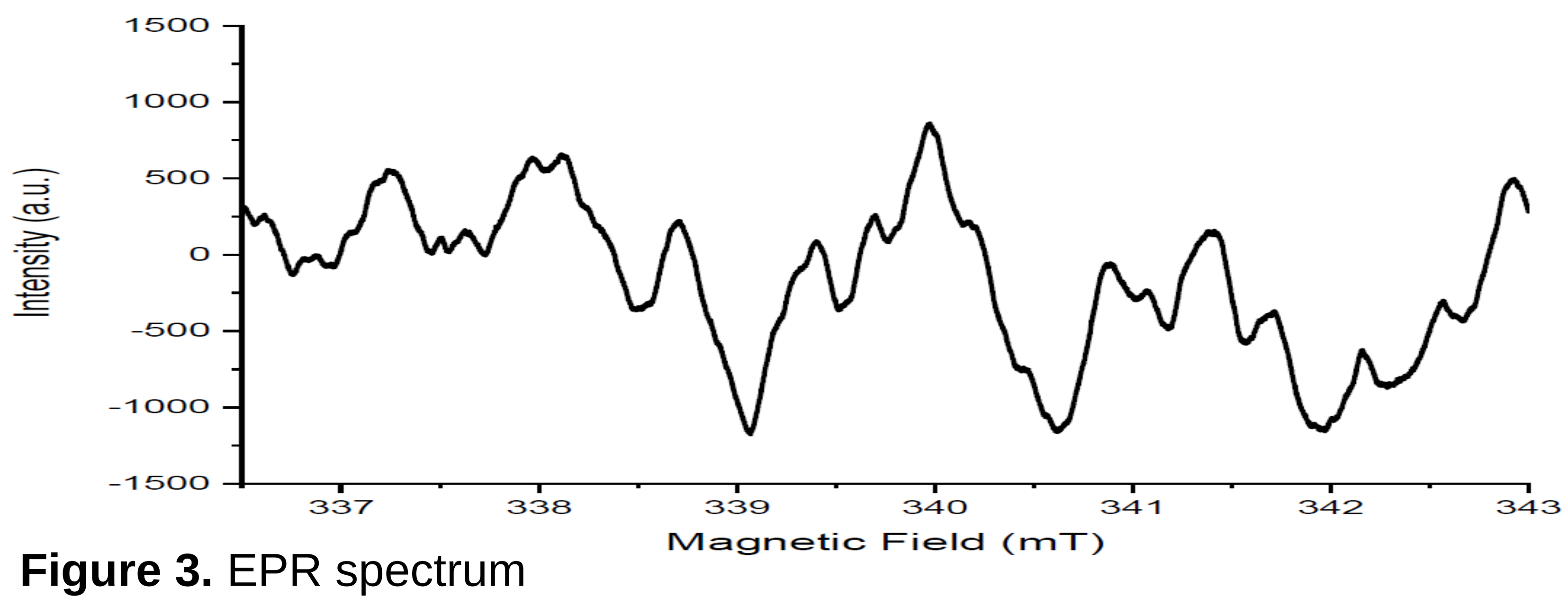

Figure 3. EPR spectrum

CONCLUSION

Regularly distributed zinc oxide nanostructures were formed on the porous silicon surface. It is determined that rod-shaped structures are transformed into flower-like structures. The energy stability of the surface structures was revealed using EPR spectroscopy.

FUTURE WORK / REFERENCES

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