St Petersburg
2014

1st International School and Conference
"Saint-Petersburg OPEN 2014"

“Saint-Petersburg OPEN 2014”

1st International School and Conference on Optoelectronics, Photonics, Engineering and Nanostructures

St. Petersburg, Russia, March 25 – 27, 2014

BOOK of ABSTRACTS

Academic University Publishing
St. Petersburg
2014

ISBN 978-5-906433-10-7

1st International School and Conference "Saint-Petersburg OPEN 2014" on Optoelectronics, Photonics, Engineering and Nanostructures carries on the tradition of annual conferences and schools organized at St Petersburg Academic University for students, PhD students and young scientists. The School and Conference is established and chaired by Nobel Prize laureate in Physics academician Zhores Alferov.

More detailed information on the School and Conference is presented on http://www.spbopen2014.spbau.com/

The Book of Abstracts includes abstracts of contributed works accepted for presentation at the Conference.

The volume was composed by St Petersburg Academic University from electronic files submitted by the authors. Only minor technical corrections were made by the composers.

Chief Editor: Zhores I. Alferov
Editors: Alexey E. Zhukov, Vladimir V. Korenev

Published by
St. Petersburg Academic University RAS
ul. Hlopina 8/3, 194021, St. Petersburg, Russia
http://www.spbau.ru/

Published in Russian Federation

Precise nanoporous silicon formation process for an integrated LED source

Y Mukha, A S Mohammed, A Hubarevich, A Stsiapanau and A Smirnov

Belarusian State University of Informatics and Radioelectronics, 220013 Minsk,
Belarus

E-mail: Smirnov@bsuir.by

Abstract. We propose to use nanoporous silicon (npSi)/Al Schottki structure to fabricate integrated into a Si chip light emitting source. High current densities and high concentrations of hydrofluoric acid are generally needed during the electrochemical etching process to fabricate high porosity nanostructured silicon films. However, short process time of ultrathin films formation, toxic and aggressive reagents are serious concerns associated with it. Therefore, it is highly demanded to seek alternatives to fabricate ultrathin nanoporous Si films using lower current densities at low F- ion concentrations. We have developed an ultrathin nanoporous silicon fabrication process by electrochemical etching in ammonia fluoride solution. It was shown that highly uniform and ultrathin high porosity nanoporous silicon films can be fabricated under very low current densities and fluorine ion concentration in a reproducible manner.

1. Introduction

At first porous self-organized structure on silicon was created in 1956 at Bell Laboratory. In 1990 the quantum effects and room temperature visible luminescence was demonstrated in porous silicon [1]. Our works were concentrated on avalanche type reverse biased Schottky diodes and its microdisplays and optoelectronics applications [2,3]. Standard technological parameters for formation a high porosity nanostructured Si are high current densities and high concentrations of hydrofluoric acid. These regimes are not convenient because of very short process times (some seconds for thin layers) and toxic (high HF vapor pressure), aggressive reagents (etching Al layers and interconnections) are used. However, changing to lower current densities and concentrations leads to instability and low uniformity of the process.

2. Porous silicon formation

There are three well known regimes areas in the current density- hydrofluoric acid concentration plot, which are illustrated in Fig. 1 [4]. At high densities-concentration electro-polishing takes place, at low densities-concentrations we have porous silicon formation and in the middle is a transient regime. Rectangular in the plot shows standard good reproducible, well known regimes [5], while ellipse corresponds to low uniformity processes. The area at bottom left corner isn't methodically investigated. One of the reasons of this is low buffer capacity of a very diluted hydrofluoric acid and chemical changes during the anodizing process. To avoid from "diluted" problem using of salts of hydrofluoric acid in combination with an acid with high buffer capacity is proposed.

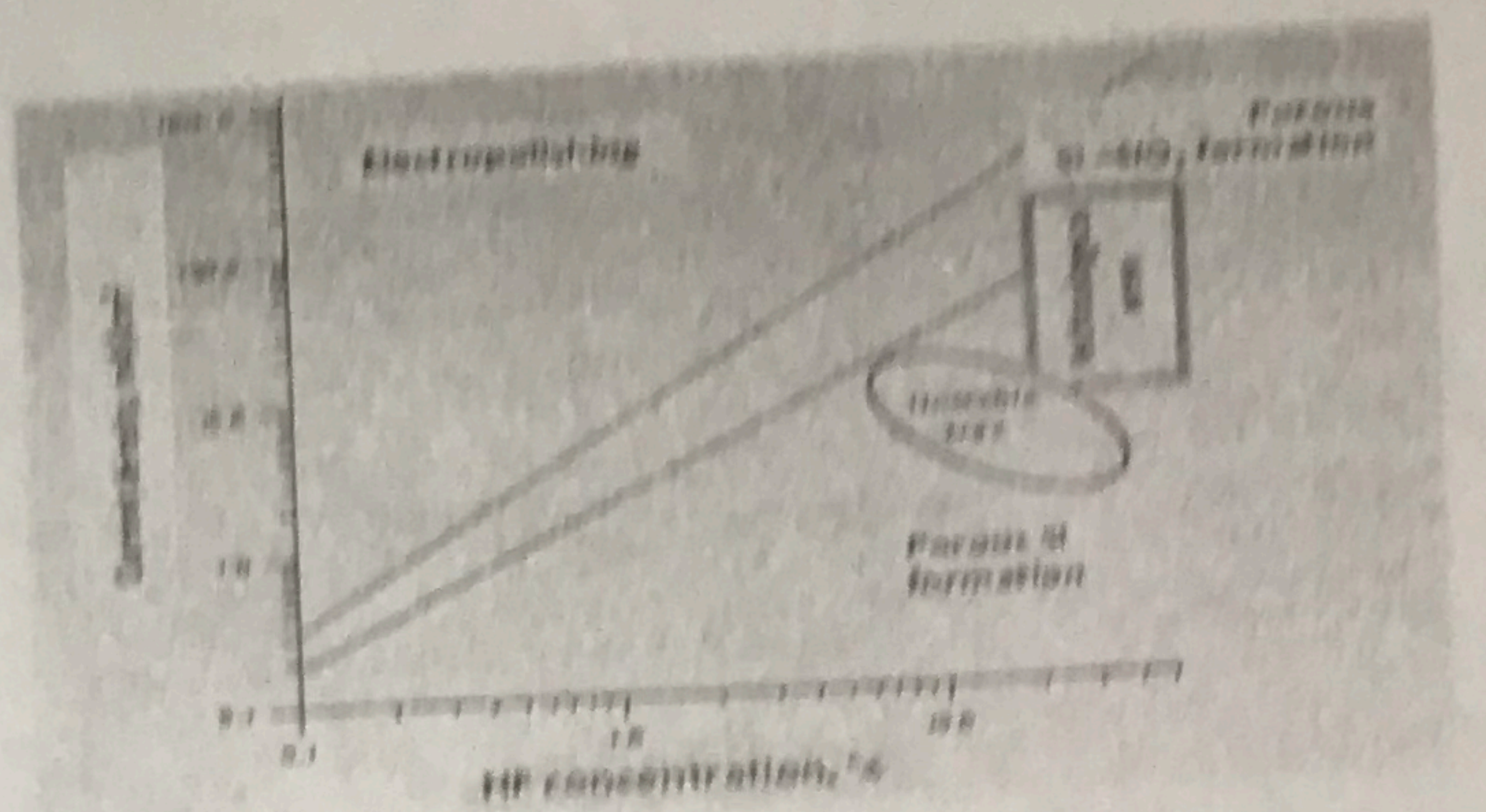

Figure 1. Different types of porous silicon formation.

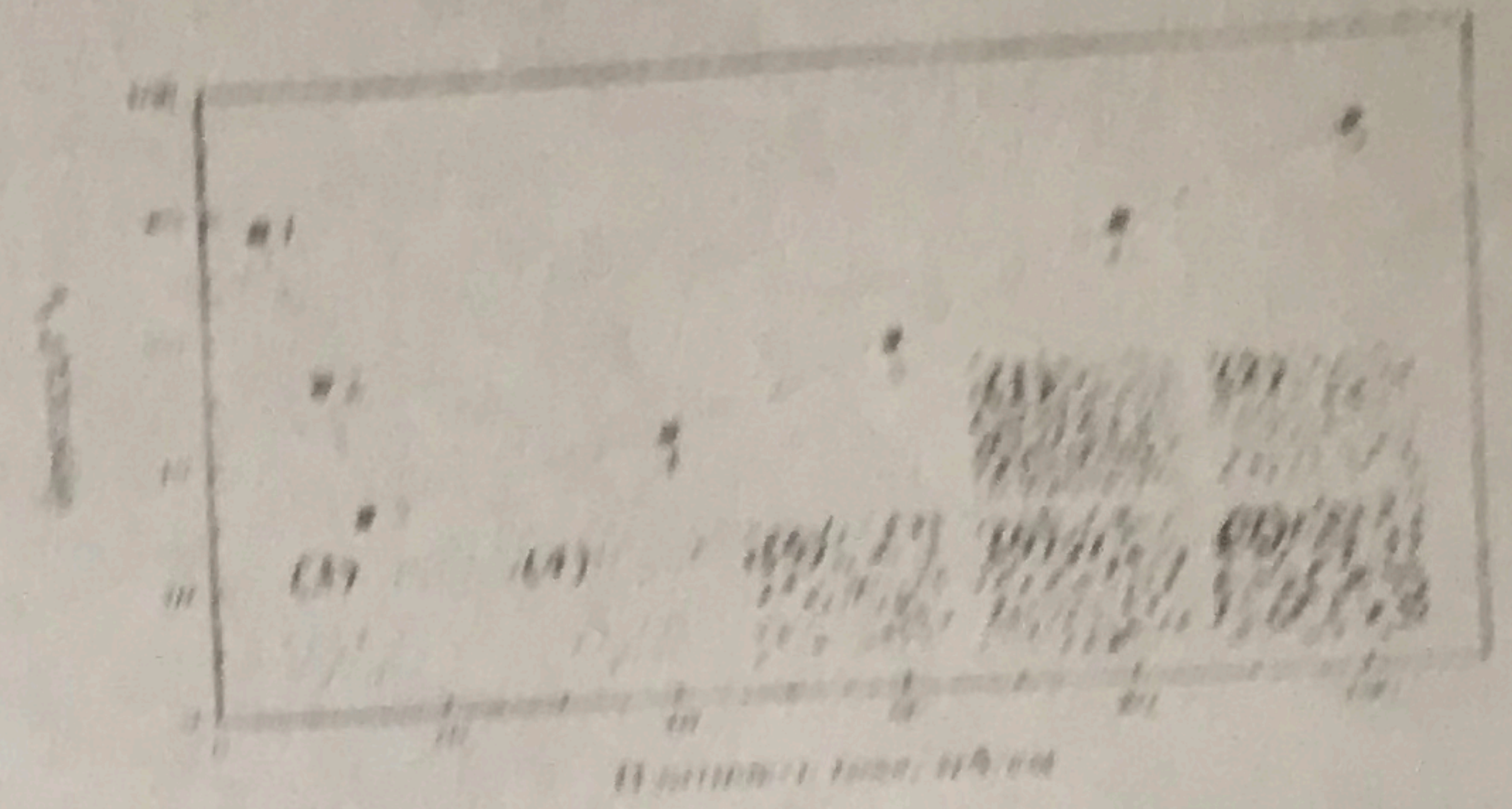

Figure 2. Porous structure versus current density.

In fig. 2 change of porosity versus anodizing current density for heavy antimony doped silicon (0.01 Ohm cm <100> orientation) in 1:2:1 HF:C_2H_5OH:H_2O is presented. Porosity anomaly versus current density is absolutely evidence. At 10 mA/cm^2 the plot turns and morphology of porous silicon changes from regular vertical holes (at higher current densities) to sponge structure (at lower current densities).

3. Results and discussion

N-type <100> oriented phosphorous doped silicon substrates (0.1 Ohm cm and 0.01 Ohm cm) were used. The samples were anodized in NH_4F:H_3PO_4:C_2H_5OH solution containing from 5to 25 % H_3PO_4 at current densities of 0.01 – 1 mA/cm^2 and ambient conditions with halogen lamp illumination. Figure 3 and 4 shows structure of PS. Pores size is 10 - 20 nm and porosity is 55 % at current density of 0.25 mA/cm^2 and 75 % at current density of 0.025 mA/cm^2.

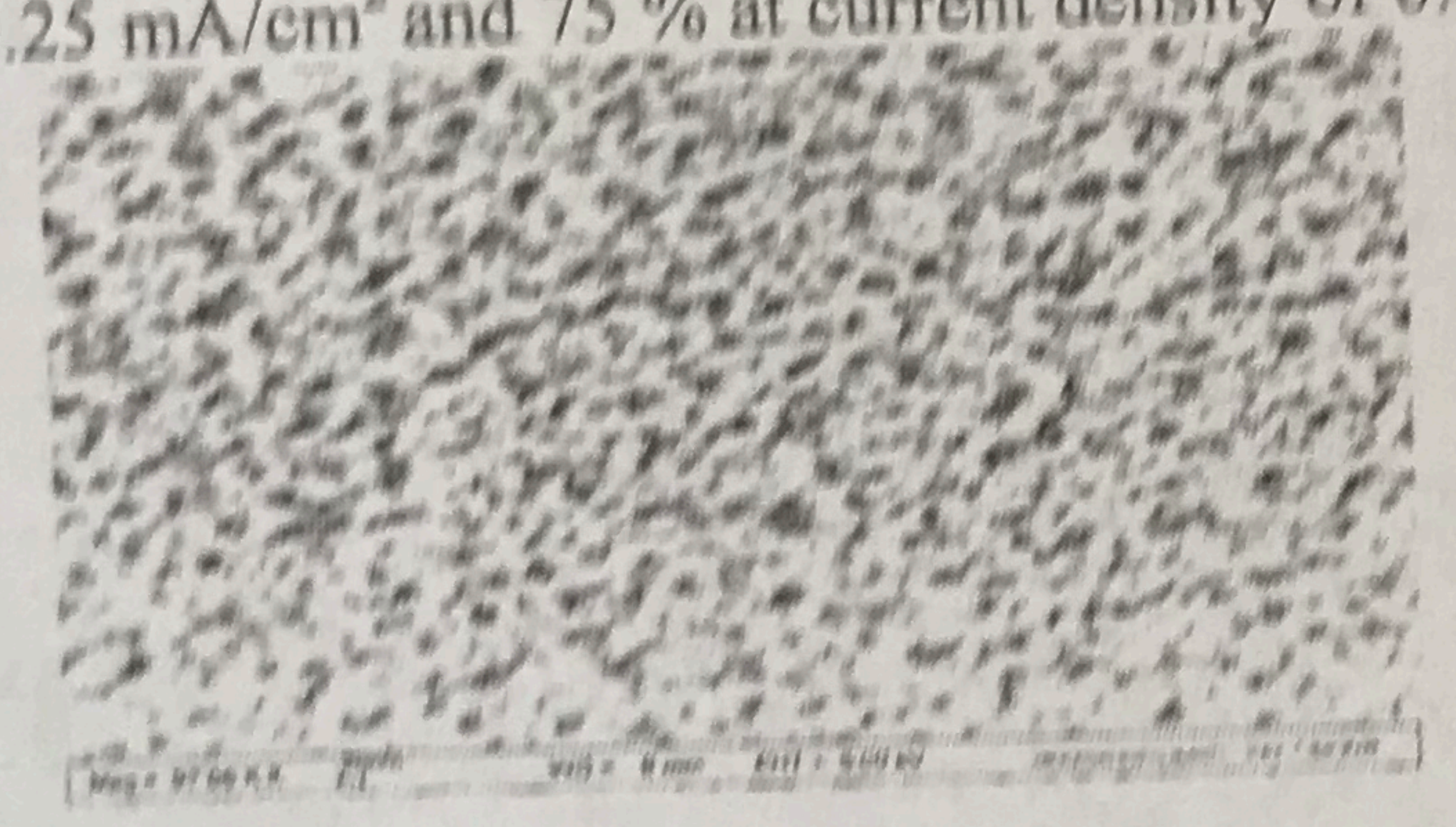

Figure 3. Structure of PS anodized at 0.25 mA/cm^2 and 5 % NH_4F: 5 % H_3PO_4:C_2H_5OH

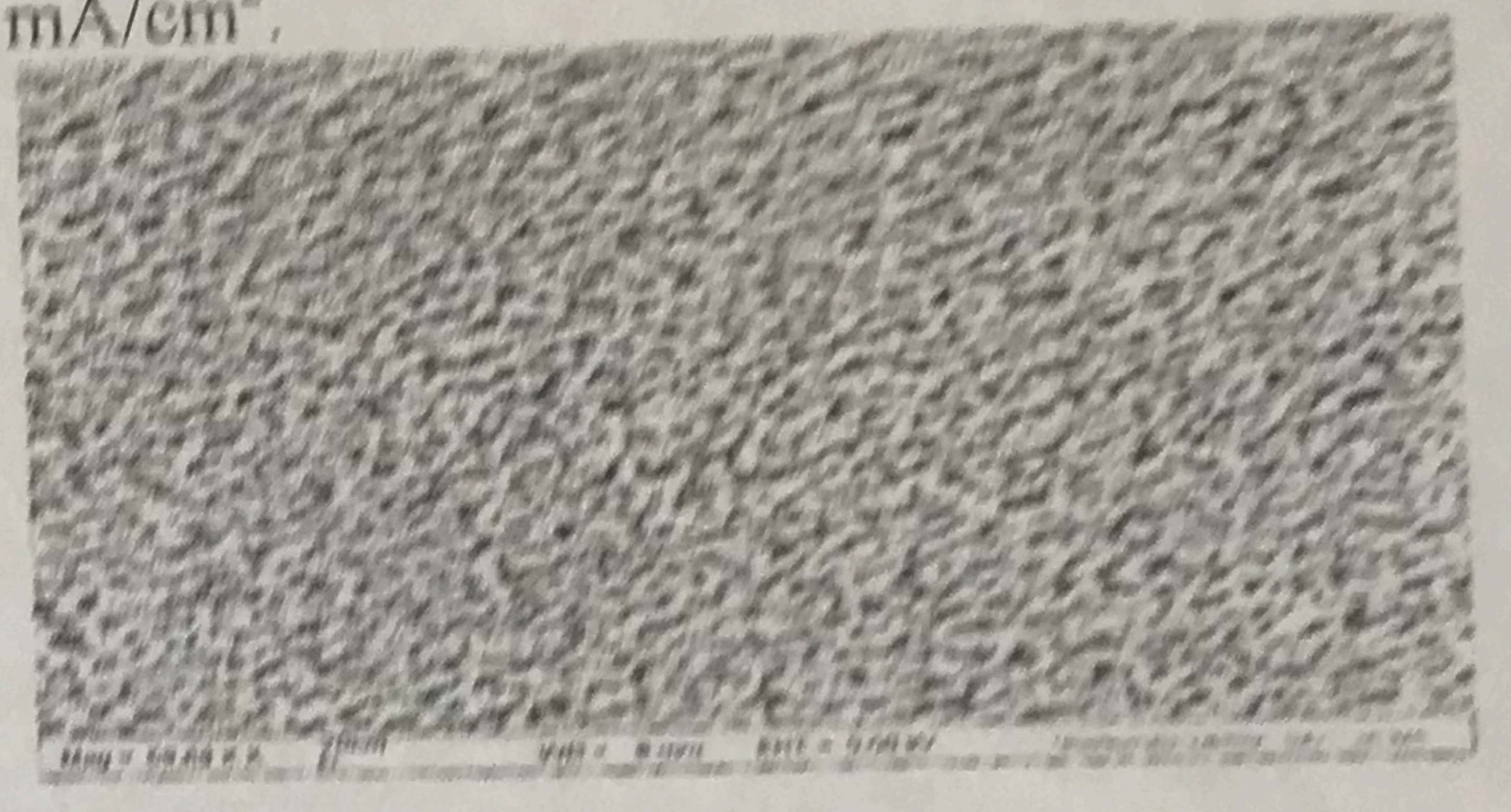

Figure 4. Structure of PS anodized at 0.025 mA/cm^2 and 5 % NH_4F: 5 % H_3PO_4:C_2H_5OH.

4. Conclusions

In this work we report the stable and reproducible regime of porous silicon layers production at ultra small current density and fluorine ion concentration. Porous silicon structures are high porosity sponge like, have ultra small thicknesses and can be used to fabricate integrated to a Si chip light emitters.

References

[1] Cullis A G and Canham L T 1991 Visible light emission due to quantum size effects in highly porous crystalline silicon *Nature* **353** 335-338

[2] Jaguiro P, Katsuba P, Lazarouk S, Farmer M and Smirnov A 2009 Si-based emissive microdisplays *Physica E: Low-dimensional Systems and Nanostructures* **41** 927-930

[3] Jaguiro P, Katsuba P, Lazarouk S, Moore S and Smirnov A 2009 Si-based optoelectronic couple *Physica E: Low-dimensional Systems and Nanostructures* **41** 1094-1096

[4] Kolasinski K W 2005 Silicon nanostructures from electroless electrochemical etching *Current Opinion in Solid State and Materials Science* **9** 73-83

[5] Kholostov K, Bondarenko V 2008 Investigation of structure of mesoporous silicon *Doklady BGUIR* **35** 72-76