Applied Surface Science 280 (2013) 655–659

Contents lists available at SciVerse ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

A Monte Carlo simulation model for surface evolution by plasma etching

Fangfang Chen[a], Kaigui Zhu[a,*], Aqing Chen[a], Weijie Huang[a], Lishuang Feng[b], Zhen Zhou[b], Guanglu Ge[c]

[a] Department of Physics, Beihang University, Beijing 100191, China
[b] School of Instrumentation Science and Opto-Electronics Engineering, Beihang University, Beijing 100191, China
[c] Laboratory of Nanostanderization, National Center for Nanoscience and Technology, Beijing 100190, China

ARTICLE INFO

Article history:
Received 20 November 2012
Received in revised form 30 April 2013
Accepted 30 April 2013
Available online 18 May 2013

PACS:
52.40.Hf
52.65.Pp
52.65.Yy
52.77.Bn

Keywords:
Plasma etching
Surface morphology
Simulation
Monte Carlo method

ABSTRACT

A Monte Carlo simulation model, i.e. sputtering etch model, was established with Monte Carlo method to simulate plasma etching induced surface morphology evolution. The surface morphology images and fractal exponents were obtained, with $\alpha = 0.5$, $\beta = 0.27$, $z = 1.76$. Germanium samples were etched in SF_6 plasma and the post-etch surface was analyzed in order to compare with the model. The surface morphology images and fractal exponents by simulation describe the experimental results very well.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

Plasma etching as an essential process of modern microelectronics has attracted considerable attention. So far, studies are mostly concentrated in the experimental study [1], including optimization of process parameters [2], exploration of new technology, related equipment design and optimization [3], and surface roughness of etching material [4,5]. Among them, the surface roughness of etching material has an important impact on device performance.

In spite of the fact that so much experimental work has been reported on plasma etching induced surface roughness, theoretical work on surface roughness evolution by plasma etching is still very limited except for a very few reports [6–8]. Zhao et al. have similar work on film growth [9,10]. They indicated that the dynamic roughening of polymer film is deeply affected by strong molecular interactions and relaxations of polymer chains [11]. Moreover, incident flux distribution, sticking coefficient, and surface diffusion were accounted for in the growth process [12,13]. They also simulated the reactive ion etching [14–16]. Recently, Tang et al. use the Kinetic Monte Carlo (KMC) simulation to study the effect of the structure of fractal substrates on dynamic scaling behavior of the surfaces [17,18]. The etching model growing on diluted squares, the Sierpinski arrowhead and crab fractal substrates are simulated. The results show that the scaling exponents of the etching model growing on fractal substrate are determined by not only the fractal dimension but also the fractal structure. However, there are few studies on simulation of plasma etching process using Monte Carlo method. In this work, we established a sputtering etch model using Monte Carlo method to simulate the plasma etching process. In order to compare the simulation results with experimental ones, we also carried out etching experiments for germanium by SF_6 plasma. It was shown that the modeling results consist very well with the experimental results.

2. Sputtering etch model

There are a few models used for surface etching and growing simulation. We start with the reactive ion etching model, in which

* Corresponding author. Tel.: +86 1082316106.
E-mail address: kgzhu@buaa.edu.cn (K. Zhu).

0169-4332/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.apsusc.2013.04.171

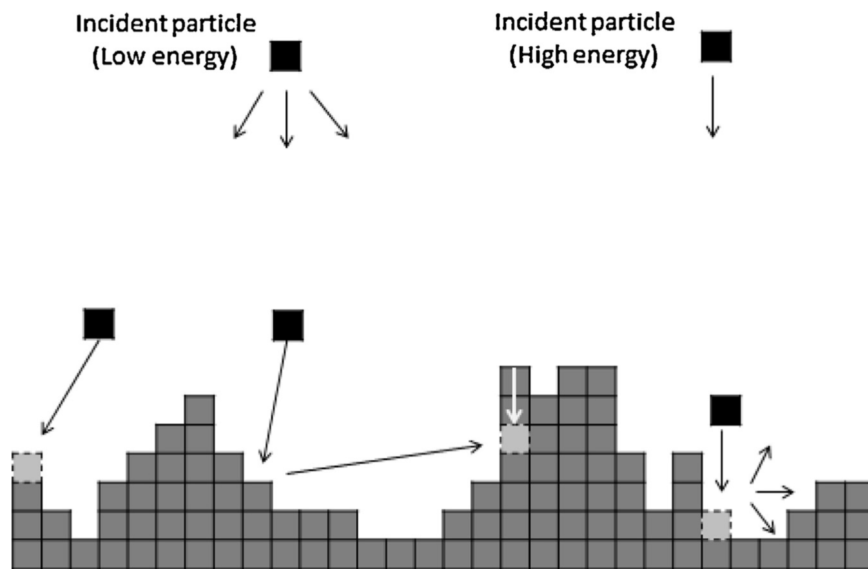

Fig. 1. Illustration of the Monte Carlo simulations for sputter etching.

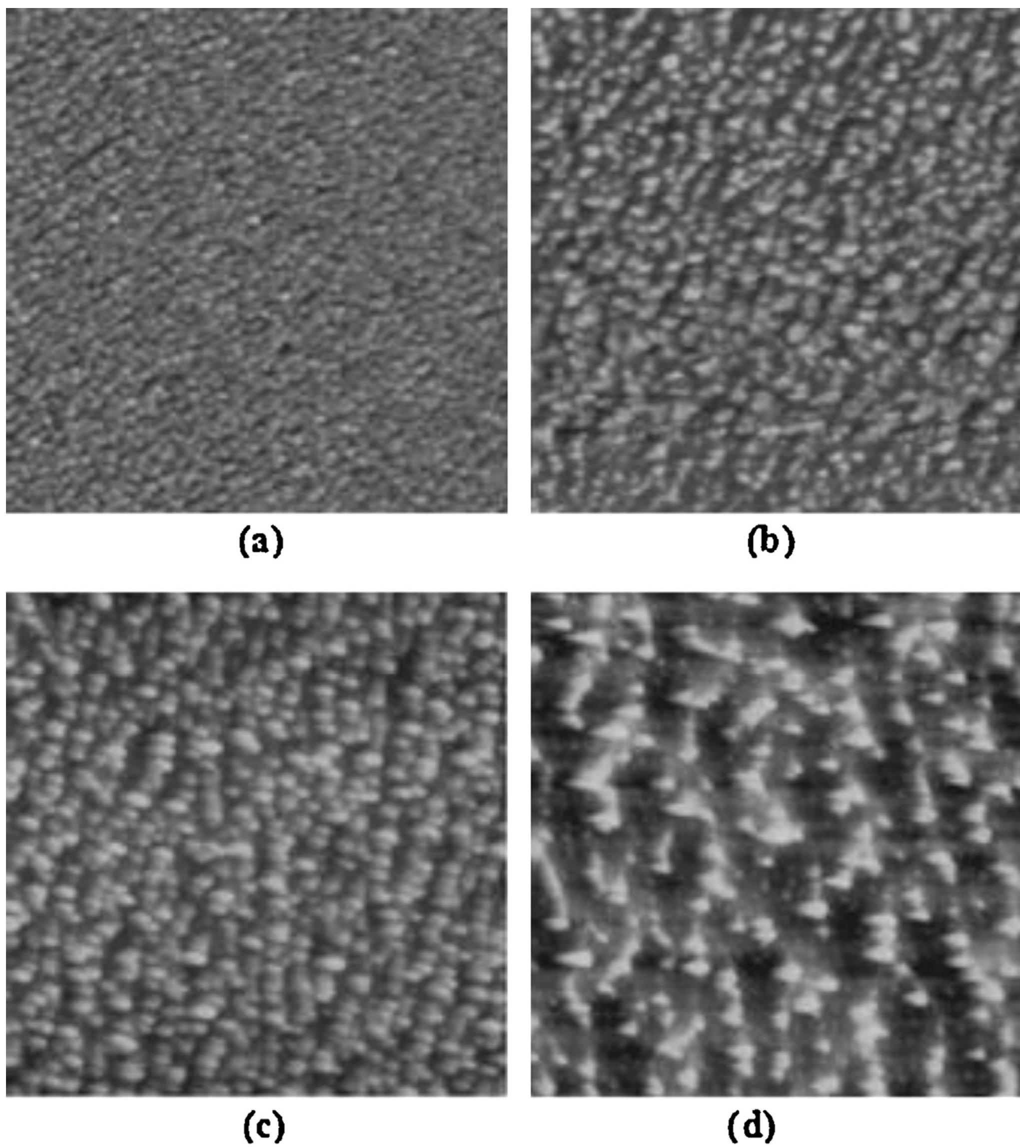

Fig. 2. Surface images of plasma etching for (a) $t = 60$ s, (b) $t = 120$ s, (c) $t = 180$ s, (d) $t = 360$ s. Light areas indicate high h, while dark areas indicate low h.

Download English Version:

https://daneshyari.com/en/article/5353051

Download Persian Version:

https://daneshyari.com/article/5353051

Daneshyari.com