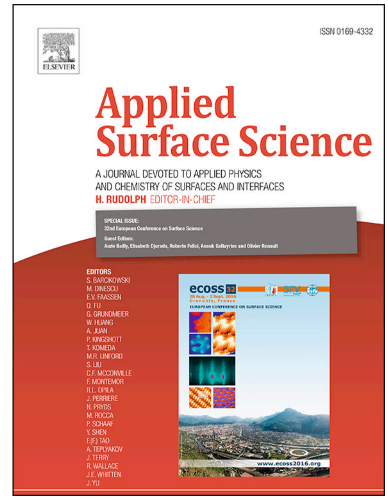
Accepted Manuscript



Laser-induced dewetting of silver-doped chalcogenide glasses

Alexandre Douaud, Sandra Helena Messaddeq, Olivier Boily, Younès Messaddeq

PII: S0169-4332(18)30814-6
DOI: https://doi.org/10.1016/j.apsusc.2018.03.129
Reference: APSUSC 38877

To appear in: *Applied Surface Science*

Received Date: 20 December 2017
Accepted Date: 17 March 2018

Laser-induced dewetting of silver-doped chalcogenide glasses

Alexandre Douaud[a], Sandra Helena Messaddeq[a], Olivier Boily[a], Younès Messaddeq[a]

[a] *Centre d'Optique, Photonique et Laser. Université Laval, 2375 rue de la Terrasse, G1V0A6, Québec (QC), Canada*

Abstract

We report the observation of laser-induced dewetting responsible for the formation of periodic relief structures in silver-based chalcogenide thin-films. By varying the concentration of silver in the $Ag_x(As_{20}S_{80})_{100\text{-}x}$ system (with x = 0, 4, 9 and 36), different surface relief structures are formed. The evolution of the surface changes as a function of laser parameters (power density, duration of exposure, and polarisation) as well as film thickness and silver concentration has been investigated. The scanning electron microscopy and atomic force microscopy images of irradiated spots show periodic ripples aligned perpendicularly to the electric field of incident light. Our results show that addition of silver into sulphur-rich chalcogenide thin-films improves the dewetting when compared to pure $As_{20}S_{80}$ thin-films. The changes in surface morphology were attributable to photo-induced chemical modifications and a laser-driven molecular rearrangement.

Keywords:
silver-doped chalcogenide, laser-induced dewetting, co-evaporation, periodic relief formation, thin-films

Introduction

The formation of periodic patterns is a fundamental and technologically significant topic with great interest over the years. This process can be achieved using several methods such as lithography or focused ion beam (FIB). Despite their effectiveness, these techniques are either time consuming and costly (i.e., FIB) or need the use of other materials and extra steps during the process such as lithography, which can be inconvenient taking into account the compatibility of the different components.

To supersede these drawbacks, an alternative technique to produce relief periodic patterns would be the use of the dewetting phenomenon in thin-films. In fact, the reduction of the total free energy when the interfacial area between the film and its substrate is reduced by agglomeration of the film into islands[1] is accomplished using a thermal source or via photo-induced effects using a laser. In a previous study, we reported the use of thermal dewetting on chalcogenide thin-films to fabricate microlenses transparent in the infrared region[2].

While the pattern formation via thermal dewetting of metal and polymer thin-films has been studied in detail, few works have been reported in the literature on laser-induced dewetting. For instance, dewetted structures following laser irradiation have been used to produce nano and micro-sized particles of noble metals[3, 4, 5] for plasmonic applications. In the case of Ag thin-films the dewetting is explained by capillary instabilities due to the high temperature reached by a pulsed laser[6].

In this paper we report the formation of laser-induced surface relief structures of glassy Ag-based chalcogenide thin-films using a continuous wave (CW) laser which are created as a result of dewetting. In contrast to the literature, we demonstrate here that Ag–As–S thin-films can be completely dewetted by a laser beam via photonic effects rather than thermal effects. Silver migration and mass transport due to an electric field gradient force was suggested to be at the origin of the observed phenomenon. In fact, the real mechanism is mainly dependant on the glass composition and conditions of processing. In this study, we will show the possibilities of tuning the period and shape of the structures by varying power density of the incident light, and the silver concentration and thickness of the Ag–As–S thin-films.

Materials and Methods

The $As_{20}S_{80}$ glass was prepared by the usual melt-quenching technique, from high purity arsenic (7N) and sulphur (5N), sealed in an evacuated silica tube, which was then heated at 675°C for 12h and air-quenched. The glass was