Spatio-temporal pattern formation under global coupling during the electrodissolution of Si

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In this experimental study, nonlinear phenomena during the electrodissolution of silicon in fluoride containing electrolytes are investigated. In the presence of a linear global coupling, realized by an external resistor, the system exhibits sustained oscillations in the average current density and in the spatial thickness distribution of the oxide layer on the anode. The oxide layer thickness is visualized in situ by means of spatially resolved ellipsometric imaging. p- and n-type Si samples are investigated. As holes in the valence band are necessary for the oxidation, the limitation of illumination imposes an additional nonlinear global coupling in case of n-type silicon. Spatio-temporal pattern formation is only observed with n-type Si and at intermediate illumination intensities.

Dependent on the position in the resistance-illumination parameter space, qualitatively different patterns in the oxide layer thickness distribution emerge. Typically, the electrode splits spontaneously into domains showing distinct intrinsic dynamic behaviour; subharmonic cluster patterns and even chimera states are observed. The classification of these domain patterns is based on simulations using a modified version of the CGLE [1]. Furthermore, the mechanistic origin of the average current oscillations is discussed.

1. V. Garcia-Morales, A. Orlov and K. Krischer, Phys. Rev. E 82, 065202(R) (2010).

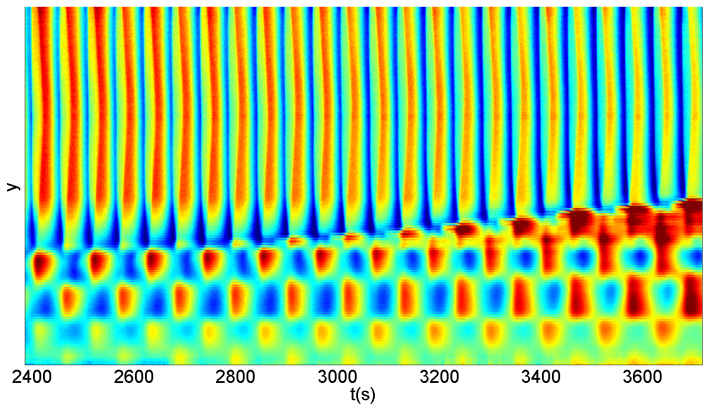

Figure 1: 1d spatial cut of the relative oxide thickness distribution on the anode vs. time. Red indicates a thick oxide and blue a thin oxide.