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CONTROL OF NANO-BLOCK TRANSPORT USING AMPLITUDE MODULATED PULSE RF DISCHARGES

Shinya Iwashita[(1, *)], Hiroshi Miyata[(2)], Kazunori Koga[(2)], Masaharu Shiratani[(2)], and Uwe Czarnetzki[(1)]

[(1)] Institute for Plasma and Atomic Physics, Ruhr University Bochum, 44780 Bochum, Germany

[(2)] Department of Electronics, Kyushu University, Fukuoka 819-0395, Japan

[(*)]**shinya.iwashita@rub.de**

We have proposed a bottom-up nanosystem-fabrication method, which consists of production of nano-blocks and radicals (adhesives) in reactive plasmas, transport of nano-blocks towards a substrate, their arrangement on the substrate using pulse RF discharges with the amplitude modulation (AM) of the discharge voltage. For the method, control of the size of nano-blocks and their manipulation without their agglomeration are important. Up to now, we have succeeded in controlling the size of nano-blocks by pulse RF discharges [1], and have realized their rapid transport from their generation region towards a substrate with suppressing agglomeration by pulse RF discharges combined with AM [2,3]. Here we report a criterion for driving nano-blocks rapidly and discuss their transport mechanisms.

Experiments were carried out using a capacitively coupled RF discharge reactor described elsewhere [1-3]. Nano-blocks were formed in 13.56 MHz RF discharges of $Si(CH_3)_2(OCH_3)_2$ diluted with Ar. Nano-block transport in AM discharges is classified into two kinds: one is the rapid transport at a velocity more than 60 cm/s during the modulation period and the other is the slow transport at a velocity of 2-3 cm/s after turning off discharges due to temperature gradient. The key parameters to the rapid transport are the period Δt and voltage V_{AM} of the modulation and asymmetry of the discharges, which is characterized by the dc self-bias voltage V_{dc}. The larger nano-blocks need the longer Δt, higher V_{AM}, and higher V_{dc} for their rapid transport because of their large inertia. Just after the initiation of the modulation, electrostatic force drives nano-blocks, and then ion drag force drives them towards a substrate. It should be noted that although most nano-blocks are neutral, some of them turn into ones charged negatively due to charge fluctuation and such nano-blocks charged negatively are driven by electrostatic and ion drag forces.

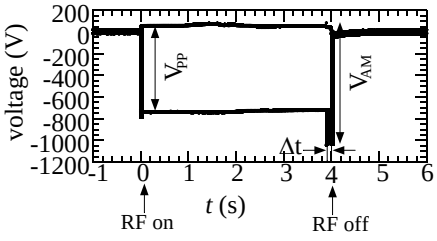

Fig. 1. Envelope of the discharge voltage.

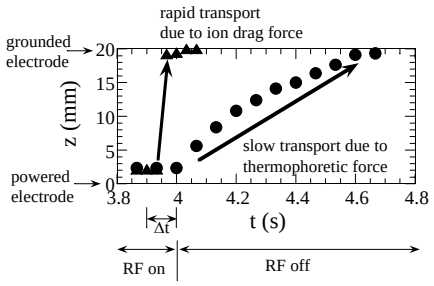

Fig. 2. Trajectories of nano-blocks in AM discharges.

References

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