Title	Plasma Liquid Crystal by Needle Shape of Particle in Gas Discharge
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Citation	電気材料技術雑誌. 2000, 9(2), p. 149-150
Version Type	VoR
URL	https://hdl.handle.net/11094/81630
rights	
Note	

電気材料技術雑誌 第9巻第2号
J.Soc.Elect.Mat.Eng. Vol.9, No.2, 2000

Plasma Liquid Crystal by Needle Shape of Particle in Gas Discharge

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Recently plasma crystal in gas discharge plasma containing dust particles has attracted much attention. The formation of a crystal structure in plasma is considered to be based on Coulombic force between dust particles which are negatively charged by the capture of electrons in gas plasma. The ionic flow also influences on the inter particle interaction. Such plasma crystals can be formed by both RF and DC discharges. The charge on each particles are dependent on the size of the particle and the discharge condition. The origin of the charge up of the particles is interpreted to be due to the difference between electron mobility and ion mobility in plasma. Depending on the discharge conditions, various types of plasma crystals such as face-centered, body centered, hexagonal structure etc. have been observed.

However, so far, as the dust particles for the plasma crystal formation, spherical shape of particles have been utilized.

We propose to use needle or rod shaped particles with various aspect ratios in stead of spherical particles. In such a case, liquid crystal like structures such as nematic liquid crystal and smectic liquid crystal can be realized, because of anisotropic interaction between particles. That is, in such a system, plasma liquid crystal may be realized.

As example of needle like material, nylon fibers of 300μm in length and 7.5 and 15μm in diameter have been used. These needles were put in the glow discharge tube of 3cm in diameter and 60cm in length which was filled with neon-hydrogen mixture gas. The electrode distance was 40cm.

Utilizing this system we can clearly observe well alignment of needles as shown in Fig.1 for an example. This is typical alignment pattern of nematic liquid crystal. In this case the inter-needle distance was slightly less than 500μm. That is, we demonstrated the possibility of plasma liquid crystal utilizing anisotropic shape of particles in glow discharge. Detailed analysis of this plasma liquid crystal such as crystal structure and charge on the needle as function of discharge parameter and dynamical behavior are now under progress.

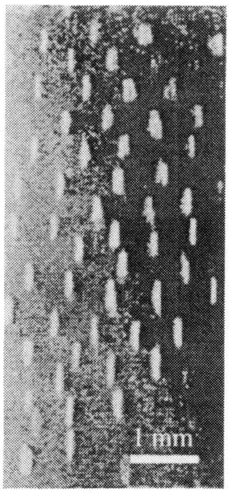

Fig.1 Photograph of plasma liquid crystal formed with nylon fibers in glow discharge

It should also be mentioned that the sort of gas used in the plasma is important. Here, we also propose various other plasma liquid crystals such as smectic and discotic liquid crystals. Smectic liquid crystal can be realized by changing the shape and property of particles and discharge conditions. Ribbon like shaped dust can also give unique alignment. Utilizing disk shaped materials plasma discotic liquid crystals can also be formed.

We are also doing experiments with the nylon needles covered with metallic layer, deposited metal layer or conducting polymer layer such as doped polypyroll.

The behavior of needles of anisotropic shape and/or property, for example needles with both ends of different diameters or different conductivity, is interesting. The use of carbon nano-tube is also exciting.

We also propose plasma photonic crystal. That is, the well aligned plasma crystal or plasma liquid crystal with the periodicity of the wave length of electromagnetic wave, the plasma photonic crystal with a photonic band gap at the wavelength range corresponding to the periodicity can be realized. In this case, the space filling factor, the ratio of the volume of particle and the volume of plasma between particles is important.

It should also be mentioned that utilizing these plasma liquid crystal and plasma liquid crystals we can separate and classify the particles ,because depending of the size and properties of particles, the trapping condition in plasma is different, which enables to separate the specific particles among distributed size and property of particles.