Cold Plasma in Solid Xenon

E.B.Gordon [a]), V.I.Matyushenko [b]), V.D.Sizov [b]), B.M.Smirnov [c])

[a]) Institute of Problems of Chemical Physics RAS, Chernogolovka 142432, Russia.
[b]) Institute of Energy Problems of Chemical Physics RAS, Chernogolovka 142432, Russia.
[c]) Joint Institute for High Temperatures RAS, Moscow 127412, Russia.

The equilibrium plasma appears if the steady ionization of a substance becomes significant, in a gas it used to be achieved at the account of temperature T growth whereas in a solid it demands the strong enhance of pressure P. The common way for non-equilibrium plasma realization is the application of an electric field accelerating free charge carriers up to the energies sufficient for new carriers' production. The study of such electric discharge in a gas allows revealing many substance properties, in particular the features of individual particles' excitations both at low and high T. Analogously the study of electric discharge in a solid should open the possibility to reveal the nature of excitations in condensed state both at low and high P.

That was the goal of our simulations [1] and experimental studies of spectra of uniform discharge through solid xenon [2, 3]. The main results are listed below:

1. Though both in gas and solid dielectrics the free electrons motion is their drift in electric field the characteristics of that drift are quite different. In both cases the electron mobility is determined by the cross-section of electron elastic scattering on heavy centers, but the interference of scattered waves in a solid causes the reduced mobility there several orders of magnitude more than in corresponded gas.
2. The maximums of electron mobility in experiment ever take place at normal densities of solid. It is suggested for the first time that this fact reflects interatomic interaction causes condensation and then crystallisation of a substance. The development of this idea will make possible the prediction of electron mobility in strongly compressed media.
3. The limiting velocity of electron drift restricting the real conductivity in condensed phase has there another origin than in a gas. In particular the direct ionization of a matrix by drifting electrons accelerated in electric field is impossible.
4. The spectral lines of atom-like and molecular-like excitons are entirely absent in the spectra of electrical discharge in solid xenon, whereas the lines of atomic ions are quite intensive and only weakly distorted by crystalline surroundings. The analysis of the spectra allowed sustaining the mechanisms of solid xenon excitation by fast drifting electrons.
5. The ionization of solid xenon by pressure is proved to be the sequence of simultaneous growth of a matrix ground state and the energy splitting in excited ionic state. The pressure of xenon metallization is quantitatively predicted as the result of these terms crossing at the interatomic distance determined for given pressure by experimental equation of state.

References:

1. E. B. Gordon, B. M. Smirnov, *JETP*, ***107****, No. 2, p. 274(2008).*
2. E. B. Gordon, V. I. Matyushenko, V. D. Sizov, B. M. Smirnov, *FNT* **34**, p.1203 (2008)
3. . E. B. Gordon, V. I. Matyushenko, V. D. Sizov, V.B.Fokin, *Optika i Spectroscopia (submitted)*