# 13 – 12. Characteristics of Solid-State Nuclear Track Detectors for Heavy Charged Particles – A Review

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**Abstract**

Since Silk and Barnes observed the tracks of uranium fission fragments on the mica films, the formation of latent tracks by heavy charged particles in solids has been recognized as one of fundamental phenomena of the radiation damage. The formation of the latent tracks became an important device for detection of charged particles by the success of etch-pit technique developed by Price and Walker.

The technique to identify incident charged particles using their latent tracks in target solid-state detectors, especially CR-39, has been developed enthusiastically and used widely in nuclear physics, nuclear chemistry, nuclear energy, space science, and archeology. While the application of this technique is prosperous, the mechanism of the latent track formation in the target solids has been investigated actively and several proposals have been given. The "ion explosion mechanism" by Fleischer, Price and Walker and the "electron thermal spike mechanism" are two mechanisms considered as fundamental even if there remain many unknown factors between the incident particles and their latent tracks in solids.

The technique to use the particle track detector in identification of charge particles is not a finished one and developing rapidly at present. We have to remember the words expressed by pioneering researchers in this field; "The first, most immediate, and visible scientific problems of the particle track field were solid state physics questions: How does a track form? What atomic processes take place? What is the ultimate atomic configuration along and around a track? Curiously enough these problems remain as some of the least studied, presumably because of the intense interest in the many applications of track etching that has directed attention to the assortment of fields considered in Chapter 4 through 10."

In this paper, we would like to summarize the mechanism of nuclear track formation and discuss possible application to identify charged particles emitted in the cold fusion reactions.

# 13 – 13. Emission of Charged Particles in the Cold Fusion Phenomenon

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**Abstract**

Charged particles have been one of the main targets of investigation to confirm nuclear reactions in the cold fusion phenomenon (CFP) from the earliest stage of the cold fusion (CF) research after 1989 when Fleischmann et al. declared the discovery of a part of the CFP. It has been very difficult to obtain reliable data of emitted charged particles due to the inevitable energy losses in the passage of the particles from the source to the detector. Solid state detectors, silicon surface barrier detectors, plastic scintillation counters, Geiger-Muller counters, and sometimes proportional counters have been used in this field with difficulty in determination of the species of the charged particles.

Recently, however, the situation was drastically changed by the use of CR-39 plastic detector. This detector is very sensitive to charged particles and convenient to use at the site of the sample where nuclear reactions supposed to occur at. Though the detector has ambiguity in determination of the energies and the species of the charged particle which produced the radiation damage, there are several works that claimed observation of protons, deuterons and alpha particles with energies of several MeV.

The characteristics of detectors for charged particles emitted from CF materials including the CR-39 detector are discussed and species of the observed particles with their energies are compared each other.

Experimental data sets of charged particle emission obtained after 1990 have been summarized and investigated from our point of view that the whole experimental data obtained in the CFP from excess energy to nuclear transmutation through emissions of neutron and light charged particles should be interpreted consistently if these phenomena have a common cause that is the physics of the cold fusion phenomenon.

We confine our investigation in this paper to the experiments where are no excitations by such particles as proton, deuteron or photon with energies more than 1 keV. In our opinion, the physics caused by energetic particles in CF materials belongs to the low energy nuclear physics under the influence of CF materials even if it is a part of the solid-state nuclear physics or condensed matter nuclear science.

# 13 – 19. Cold Fusion Phenomenon in Open, Nonequilibrium, Multi-component Systems – Self-organization of Optimum Structure

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**Abstract**

The cold fusion phenomenon (CFP) is known to occur only in specific systems satisfying several necessary conditions. The most important characteristic, which is well-known but sometimes put aside not explicitly taken into consideration, is that the system is open, nonequilibrium, multi-component one where the self-organization works to realize an optimum structure for the effects. There have been discovered three empirical laws in the CFP; (1) the stability effect of nuclear transmutation products, i.e. the more stable the nuclide, the more often generated by the nuclear transmutation in the CFP, (2) the $1/f$ dependence of the detection frequency on the intensity of the excess heat production, i.e. the number of events producing an excess power $P$ is proportional to the inverse power of $P$ with an index of about 1, and (3) the bifurcation of intensity of events (neutron emission and excess energy production) in time, i.e. the intensity of an event of a phenomenon bifurcates into two, four, eight branches in time and finally reaches a chaotic state if the condition lasts long enough. We are able to investigate the CFP as a complexity referring to the suggestion given by the three laws and conclude that the cold fusion phenomenon belongs to the complexity induced by nonlinear interactions between agents of the system composed of regular arrays of transition metals interlaced with those of hydrogen isotopes in an open, non-equilibrium condition. The characteristics of the CFP such as necessity of high ratio of D/Pd or H/Ni, preference of higher temperature of the system, and occurrence of positive feedback are investigated using our knowledge of the microscopic structure of the CF materials where occurs the CFP consulting to the complexity studied in non-linear dynamics in relation to the three empirical laws.

The controversial lack of reproducibility of the events in the CFP is a natural result of the complexity in which the cause-effect relation is characterized by stochastic processes resulting in statistical reproducibility of a phenomenon. The explosions observed several times in the history of CF research have been another riddle casting serious doubt to the reality of the CFP. This occurrence of tremendous release of excess energy in an instant is explained by the positive feedback of the reaction processes occurring in the system corresponding to the chaotic state of a nonlinear dynamics.