Experimental challenge for developing photoinduced phase transition (PIPT) materials

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An attractive target for materials science is to achieve control of the phase transition by light (photo-induced phase transition: PIPT). Till date, PIPT dynamics has been mainly governed by the rather slow process of relaxation/dissipation of photo-injected energy leading to the decoherence of the multi-electron state in the cooperatively interacting system (Classical PIPT) as shown in Figure 1. Of course, classical PIPT/cooperative phenomena have been observed widely in various class of materials including polymer, liquid crystals, Charge Transfer (CT) complexes, metal-ligand complexes and transition metal oxides/chalcogenides. Some part of them have been already utilized in application for memory devices and liquid crystal filter production process. In the first part of this report, we review the various fruitful results of Classical PIPT including ‘hidden state’ identified by ultrafast structural dynamics mainly from the view point of materials science.

Classical PIPT shows various attractive natures, however, utilization of the initial quantum dynamics of the multi-electron state (Quantum-PIPT: see Figure 2) coherently and strongly coupled with electro-magnetic field vibration of excitation photon itself is essential in order to realize the photonic phase switching and photon-energy conversion materials with ultra-high speed and sensitive response. Combined ultrafast modifications of Charge-Structure-Spin (C-S-S) within the vibrational period of elementary excitations will lead to finding unique C-S-S ordered states, which can be obtained only by the Quantum-PIPT (i.e., Quantum Hidden State: QHS). In the second part, we introduce the challenging experimental works for developing Quantum PIPT system by virtue of ultrafast light technologies including femtosecond electron diffraction.

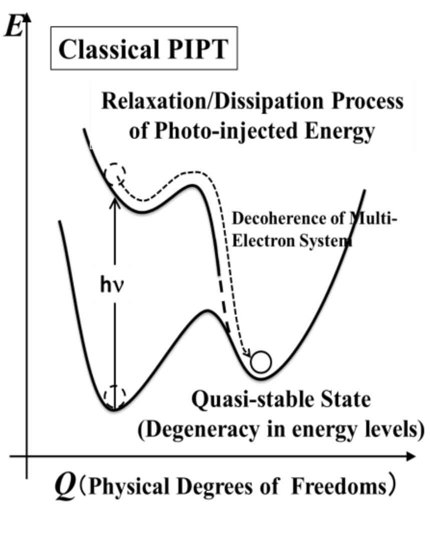

Fig.1: Concept of Classical-PIPT dynamics driven by relaxation/ dissipation (incoherent) process.

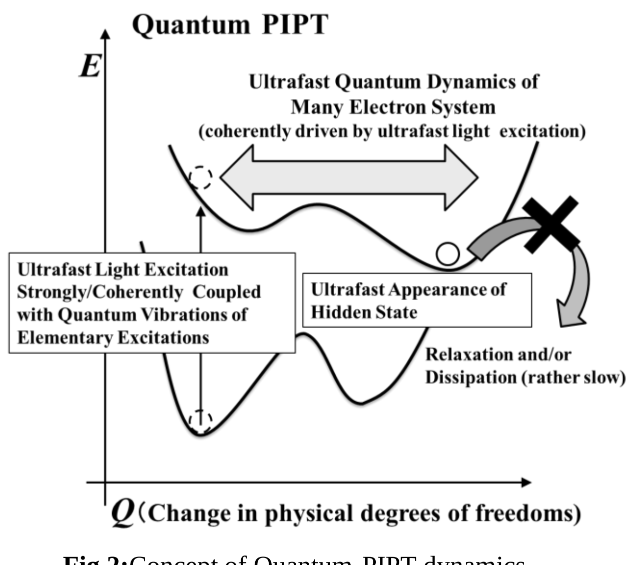

Fig.2: Concept of Quantum-PIPT dynamics which occurs before energy relaxation/dissipation , i.e. decoherence of multi-electron state.