Random telegraph signal noise (RTN) has been continuously studied for a long time due to its serious impacts on ultra-scaled circuits and non-volatile memories [1-4]. With the traditional simplified RTN model, no correlations of parameters can be observed with mass data, such as time constants and couplings to the gate bias. On the one side, it could be attributed to trap diversities since it is still unknown if we are talking about traps with same physical mechanisms. On the other side, traditional RTS noise model might be inaccurate to describe actual trapping process. In this work, aiming at further understandings on RTN physical mechanisms, comprehensive studies are done on RTN with main focus on traps time constant variations, including its strong correlations to thermal activation energies.

In Fig.1, the simplified RTN model is shown, together with definitions of time constants (tτ, τc, τc/τe, τ0) and their couplings to applied gate biases (ατ, ατc, ατc/τe). From scatter plot of τ0 and Ec, no correlations can be observed with large τ0 variations can be obviously observed. With detail experiment data, it is confirmed that interface trap densities or surface orientations has no impacts on the τ0 distributions, except thermal activation energies (Ec, ατ, Ec, ατc). As shown in Fig.2, strong correlations between τc and Ec can be observed with a narrow distribution strip. The upper limit of the distribution strip can be understood by taking the measurement window and band-gap shrinking impacts into account. The measurement window is determined by the measurement sampling rate, while the band-gap shrinking at the interface will shift the defect level. An Interesting thing is that there exists a void region under the distribution strip. This can be explained by the multi-phonon-assisted model [5-6], which indicates that the time constant τc should be expressed as τc~exp(Ec/kT)exp(xc/x0), where xc is the trap depth form Si-SiO2 interface and x0 is the dioxide thickness. This means that for traps with same Ec, τc increases along with its location depth. In other words, for traps with slow τc, only those with large Ec can be detected due to dioxide thickness limitations.