Copper is a harmful impurity in modern IC technology as it degrades gate oxide integrity and causes increased junction leakage. To be able to detect copper contamination by contactless minority-carrier lifetime methods is a fascinating idea, as measurements are fast, non-destructive, and sensitive to measured defect concentration making them a suitable/perfect characterization tool for the industrial environment. However, conventional recombination studies show weak dependence of low copper concentration on minority carrier lifetime in p-Si [1]. Recently, it was observed by surface photovoltage method (SPV) that optical activation drastically enhances recombination activity in p-Si [2,3].

We present here a method, which can be used to detect copper contamination in p-type silicon by microwave photoconductive (µPCD) -method in conjunction with high-intensity bias light. The method is based on our observations that in presence of small oxygen precipitates high-intensity light can be used to activate precipitation of interstitial copper. The precipitation follows Ham’s kinetics and results in an increase in the recombination rate (Fig. 1), which is detectable even with very low copper concentrations. Figure 2 shows a decrease in the recombination rate for different time periods after copper in-diffusion and deposition of negative surface charge. The time constant of the decrease corresponds the diffusivity of interstitial copper indicating that the decrease in the recombination rate is due to out-diffusion of interstitial copper. The studies of out-diffusion of copper show that copper concentration well below $10^{15}$ cm$^{-3}$ can be detected by this method. The method is applicable also in case when copper has completely out-diffused to the wafer surfaces, as we demonstrate that it is possible to in-diffuse copper back into the wafer bulk by external corona charge (Fig. 3).

In n-Si copper precipitation can occur without optical activation as Fermi level is close to the electroneutrality level even in samples with very low copper concentrations [4]. Similarly, we suggest that in p-Si the enhancement in copper precipitation during optical activation is due to the increase in electron Fermi-energy close to electroneutrality, which diminishes the electrostatic repulsion between positively charged interstitial copper atoms and precipitates. Our studies on the effect of the intensity of the optical activation light on the precipitation rate show that with lower intensities the activation is not so efficient as generated excess-carrier density is lower and the corresponding increase in Fermi-energy is smaller. Above certain intensity we do not observe any increase in the recombination rate with increasing light intensity, as precipitation becomes diffusion limited and recombination becomes dominated by Auger recombination.

As precipitation follows Ham’s kinetics, we can study the time constant of precipitation and its dependence on oxygen precipitates size and density as long as precipitates are small enough not to enhance recombination by themselves.
