























tivity, the Er site does not depend on the Xe implantation fluence, at least for the fluence range explored in this work.

In Fig. 5 the thermal evolution of the Er–O<sup>I</sup> and Er–Si<sup>I</sup> coordination numbers in the first shell are plotted together with the PL intensity for the Er/Xe HD sample. A good direct correlation between PL efficiency and the Er–O<sup>I</sup> is shown, indicating that the main contribution to the PL intensity comes from a properly structured Er<sup>3+</sup> environment, i.e., when the fully octahedral configuration of the oxygen atoms around each erbium ion is reconstructed by the thermal annealing, with the consequent fading of the Er–Si<sup>I</sup> contribution, the Xe-implanted Er-doped silica recovers a PL efficiency (both intensity and lifetime) very similar to the nonimplanted Er reference sample.

#### 4. Conclusion

We investigated the thermal evolution of the Er<sup>3+</sup> PL emission in silica under the influence of implantation with Xe ions at different fluences. In particular we found that Xe implantation is remarkably different with respect to an equivalent Au implantation that is carried out so as to release approximately the same level of implantation damage. In particular, Xe is not able to produce energy transfer to Er<sup>3+</sup> under non-resonant excitation, at variance with the Au case, despite the close similarity in terms of the size of the precipitates evidenced by TEM under Xe- or Au-implanted samples. This result clearly demonstrates that the energy transfer responsible for out-of-resonance excitation of Er<sup>3+</sup> cannot be ascribed to implantation induced defects but is actively triggered by ultra-small molecule-like Au clusters, which absorb the non-resonant excitation and efficiently transfer it to Er<sup>3+</sup> emitting centers.

To confirm this picture, we followed the evolution of the Xe implantation-induced damage around the Er<sup>3+</sup> site in silica. EXAFS analysis demonstrated the presence of two different short-range coordinations in the Er site: one Er–O coordination at  $R = 2.14\text{--}2.18$  Å, that is in the typical range of distance for Er<sup>3+</sup> in silica, and one longer coordination with Si atoms at  $R = 2.7\text{--}2.8$  Å. In particular the Er–Si coordination progressively fades as the annealing temperature is raised. A second coordination shell indicates that O and Si atoms in the first shell are further bonded with the matrix network. The monotonic increase of the PL intensity as a function of the annealing temperature in the Xe-implanted samples is found to be correlated to the increase of the Er–O coordination number and to the decrease of the Er–Si coordination, suggesting that these two configurations greatly affect the Er emission efficiency recovery.

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