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Nanoscale control of energy and matter in plasma-surface interactions: towards energy-efficient nanotech

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This presentation focuses on the plasma issues related to the solution of the grand challenge of directing energy and matter at nanoscales. This ability is critical for the renewable energy and energy-efficient technologies for sustainable future development. It will be discussed how to use environmentally and human health benign non-equilibrium plasma-solid systems and control the elementary processes of plasma-surface interactions to direct the fluxes of energy and matter at multiple temporal and spatial scales. In turn, this makes it possible to achieve the deterministic synthesis of self- organised arrays of metastable nanostructures in the size range beyond the reach of the present-day nanofabrication. Such structures have tantalising prospects to enhance performance of nanomaterials in virtually any area of human activity yet remain almost inaccessible because the Nature's energy minimisation rules allow only a small number of stable equilibrium states. By using precisely controlled and kinetically fast nanoscale transfer of energy and matter under non-equilibrium conditions and harnessing numerous plasma- specific controls of species creation, delivery to the surface, nucleation and large-scale self-organisation of nuclei and nanostructures, the arrays of metastable nanostructures can be created, arranged, stabilised, and further processed to meet the specific requirements of the envisaged applications. These approaches will eventually lead to faster, unprecedentedly- clean, human-health-friendly, and energy-efficient nanoscale synthesis and processing technologies for the next-generation renewable energy and light sources, biomedical devices, information and communication systems, as well as advanced functional materials for applications ranging from basic food, water, health and clean environment needs to national security and space missions.