Silicon powder recovered from end-of-life photovoltaic panels as anode material for lithium ion batteries

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In recent years, natural graphite has been widely used for the anode of lithium-ion batteries (LIBs). However, graphite has been classified as a Critical Raw Material (CRM) and therefore its partial or total replacement with non-critical or end-of-life materials is recommended. Several studies in the literature have reported the possibility of making the anode for LIBs using silicon-based materials, in particular with nanometric grain size, in order to completely or partially replace graphite. Nanosilicon powder is one of the most promising materials to replace natural graphite. It is known that silicon can form alloys with lithium, with a theoretical specific capacity of 4200 mAh g^{-1}. This value is significantly higher than the theoretical specific capacity of graphite (372 mAh g^{-1}) and of lithium metal (3800 mAh g^{-1}). The limiting factor of silicon, as an anodic material, is constituted by its volumetric expansion which can reach values up to 300% during battery charge/discharge cycles. Such a high volumetric variation involves progressive fragmentation and loss of active material (which remains electrically isolated from the rest of the electrode) with the progress of charge/discharge cycles, resulting in a rapid decrease of the accumulated capacity. In addition, the significant volumetric expansion causes continuous break of the passive film (SEI) at the electrolyte/electrode interface. The recent inclusion of silicon into the list of critical materials makes the recovery and recycling of this material extremely interesting, especially from End-of-Life (EoL) PV panels. In fact, the world's total installed PV capacity exponentially increased since 1990: it reached 512.3 GW by the end of 2018 (IEA, 2019) and is expected to rise further to 1.6 TW by 2030 and 4.5 TW by 2050 (IRENA, 2016). Taking into account that the mean lifetime of PV panels is 25 years and considering the dramatic growth experienced in the PV industry since 2000, significant quantities of photovoltaic panel waste will be produced within a few years and will continuously increase in the future. One of the challenges faced by IEMAP (Italian platform for the accelerated discovery of materials for energy project), funded by the Italian Ministry of the Environment within the Mission Innovation Program, is therefore the development of a sustainable process of mechanical processing of silicon-based powder from EoL PVs, without use of harsh treatments. The opportunely processed powder is re-used to obtain anodic material, capable of intercalating lithium ions, for the realisation of anodes with high specific capacity for high energy density batteries.