The world needs to move from a fossil fuel-based to a renewable energy-based society. With the increasing electricity production from wind and PV, short and long-term energy storage is becoming one of the main challenges of the 21st century. While batteries are the preferred method for short-term storage, a different technology is required for seasonal storage. Hydrogen is a valuable energy carrier, owning its high energy density (122 kJ/g). However, compact and safe storage of H₂ is challenging. Complex hydrides are especially attractive for solid-state H₂ storage due to their high gravimetric and volumetric hydrogen density. Sodium borohydride (NaBH₄) contains more than 10 mass% of H₂, but high temperatures are needed to release the H₂ (505°C). The work presented in this thesis focused on the combination of borohydride and ionic liquid (IL) cations, in order to modify the stability of borohydride. The materials developed in this thesis are able to release H₂ at moderate temperature (< 100°C), thanks to the charge transfer between the IL cation and borohydride, making them interesting candidates for solid-state H₂ storage. In addition, I will present the unique reactivity of these IL borohydrides with CO₂. Due to the destabilization of the B-H bond, direct CO₂ capture and reduction can be achieved under ambient conditions. Up to three CO₂ molecules are fixed per borohydride anion, even at low CO₂ concentrations. The obtained reaction product can be easily transform to formic acid (HCOOH), or used as formylation agent in organic synthesis. These results represent a promising path for CO₂ capture and valorisation.

References:

Born in 1992, Sion, Switzerland. Loris Lombardo graduated M.S degree in Molecular and Biological Chemistry from Ecole Polytechnique Fédérale de Lausanne (EPFL), in 2017. During this time, he worked in the fields of catalysis for CO₂ reduction, water splitting, and biomass conversion. His research during the PhD is focused on complex hydride for hydrogen storage and CO₂ reduction at EPFL, Switzerland in the group of Prof. Andreas Züttel. He defended his PhD thesis on 25 Jan. 2021.