Fig.S1 The relationship between temperature and conductivity of the oxidized $Nb_{1.33}Ti_{0.67}O_4$ (Nb_2TiO_7) sample.

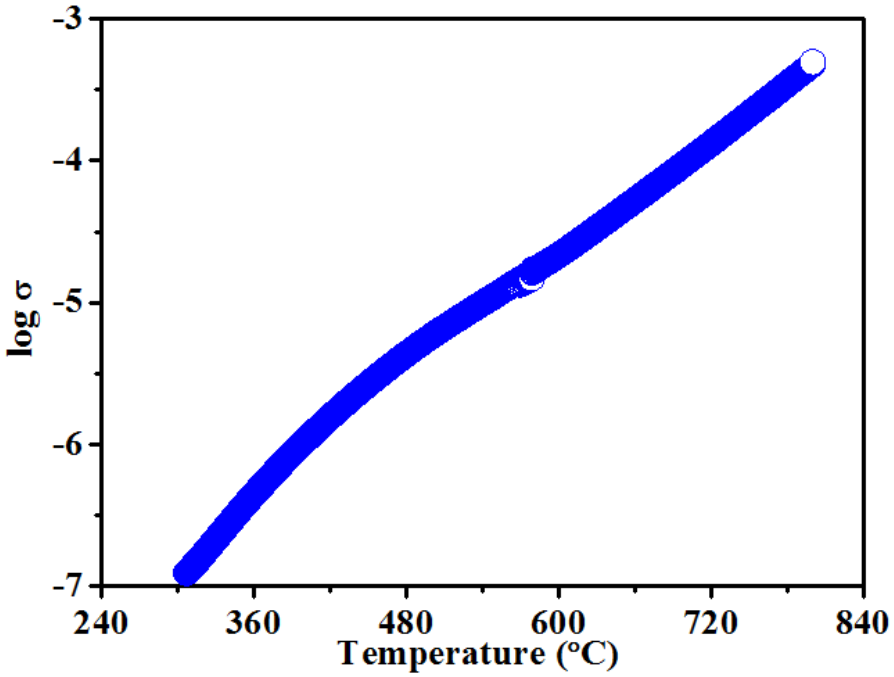

Fig.S2 The relationship between temperature and conductivity of oxide $NbTi_{0.5}Ni_{0.5}O_4$ sample.

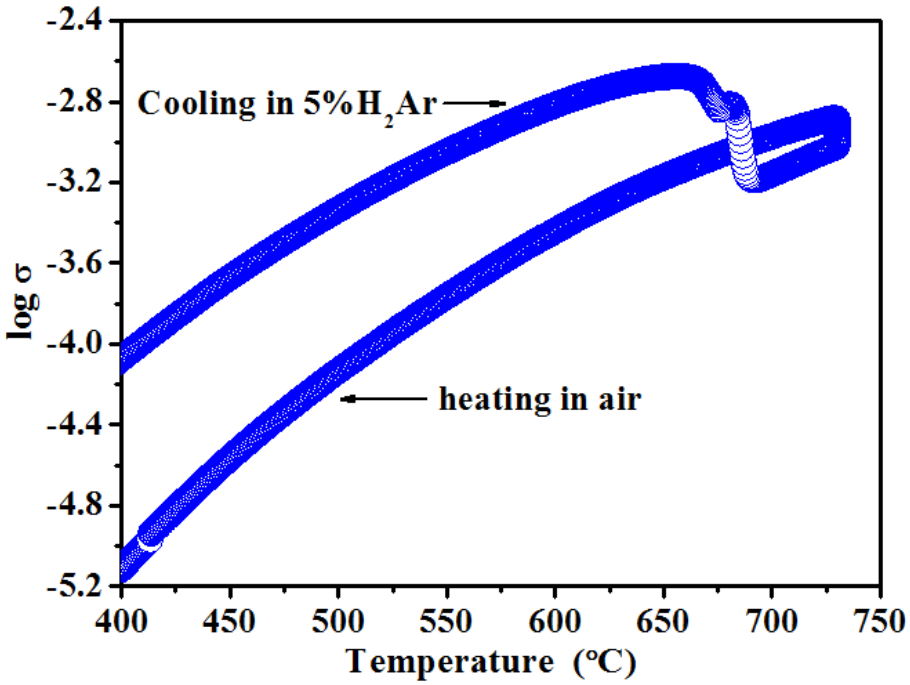

Fig.S3 The relationship between temperature and conductivity of the $NbTi_{0.5}Cu_{0.5}O_4$ sample which was exposed to $5\%H_2/Ar$ when the temperature reaches 730°C.

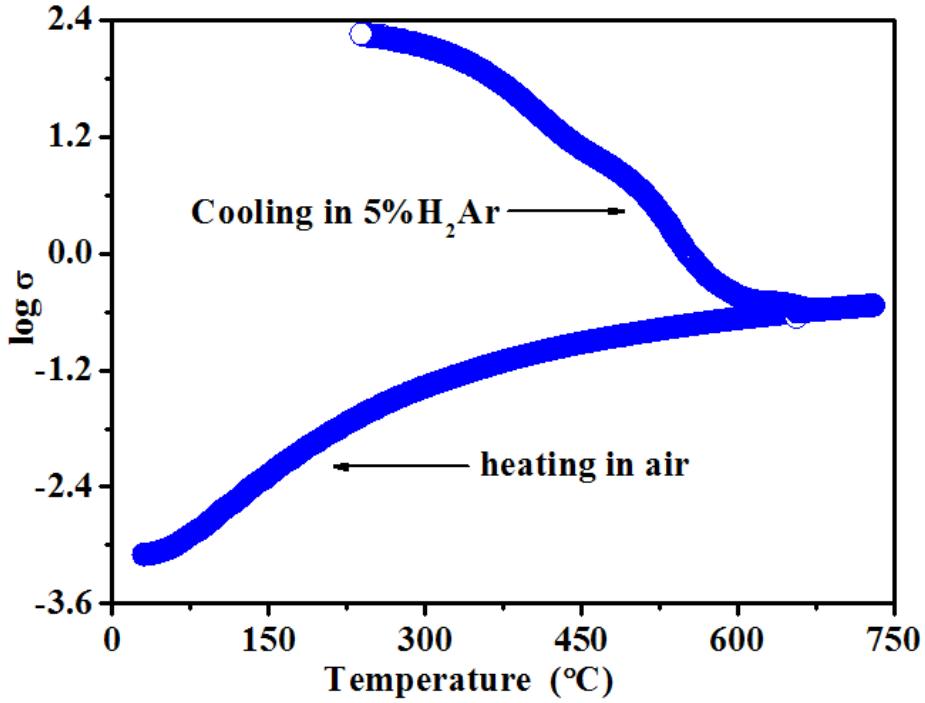

Fig.S4 AC impendence of the symmetric solid oxide cells NTO-SDC/YSZ/ NTO-SDC tested at 800 ^{o}C in pure H_2 under different current densities, where the NTO is $Nb_{1.33}Ti_{0.67}O_4$.

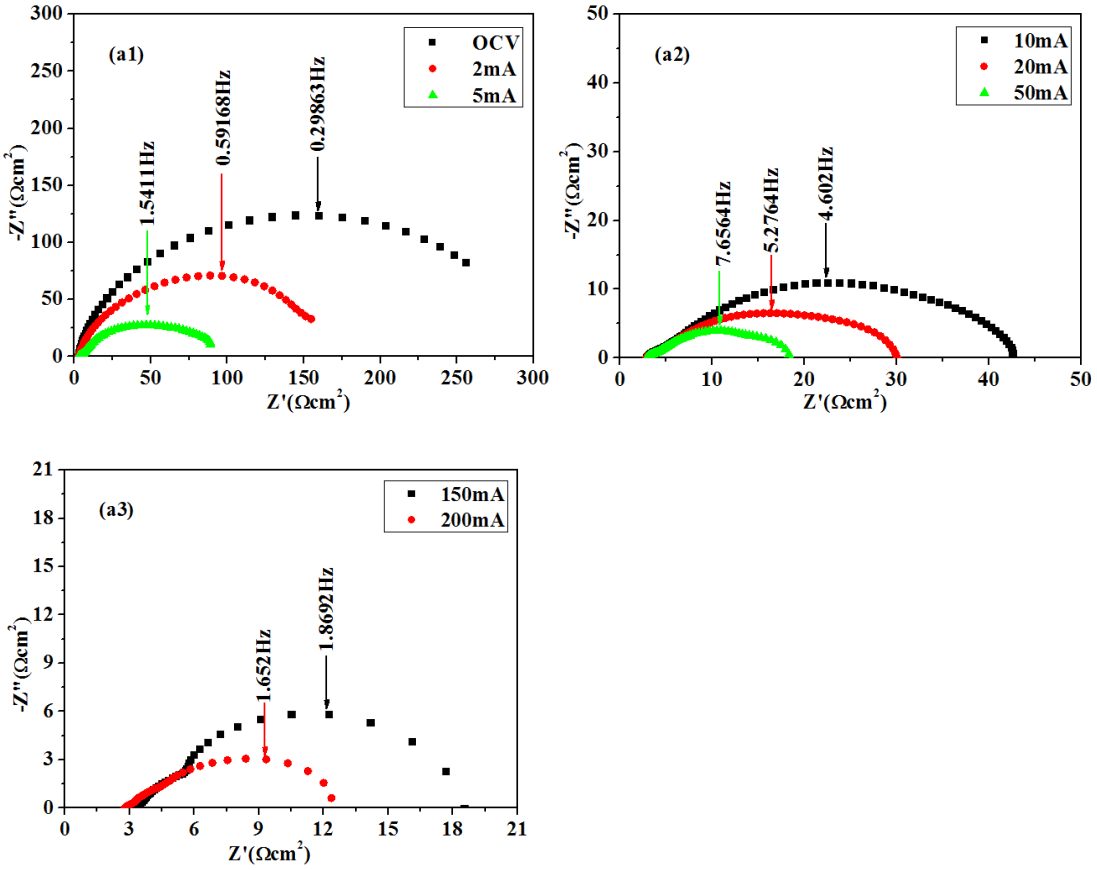

Fig.S5 AC impendence of the symmetric solid oxide cells NTO-SDC/YSZ/ NTO-SDC tested at 800 ^{o}C at OCV under different hydrogen partial pressure, where the NTO is $Nb_{1.33}Ti_{0.67}O_4$.

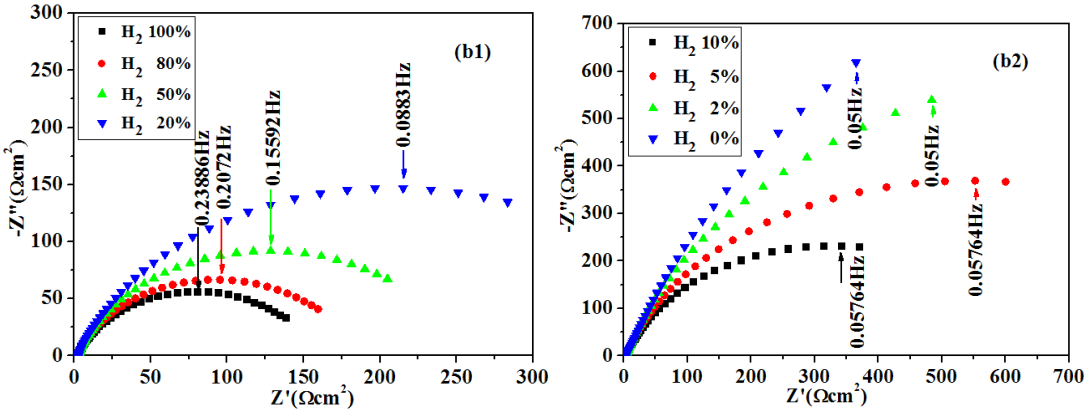

Fig.S6 I-V curve of the solid oxide electrolyzer based on Ni-SDC fuel electrode for steam electrolysis (4%H_2/Ar/3%H_2O) at 800 ºC.

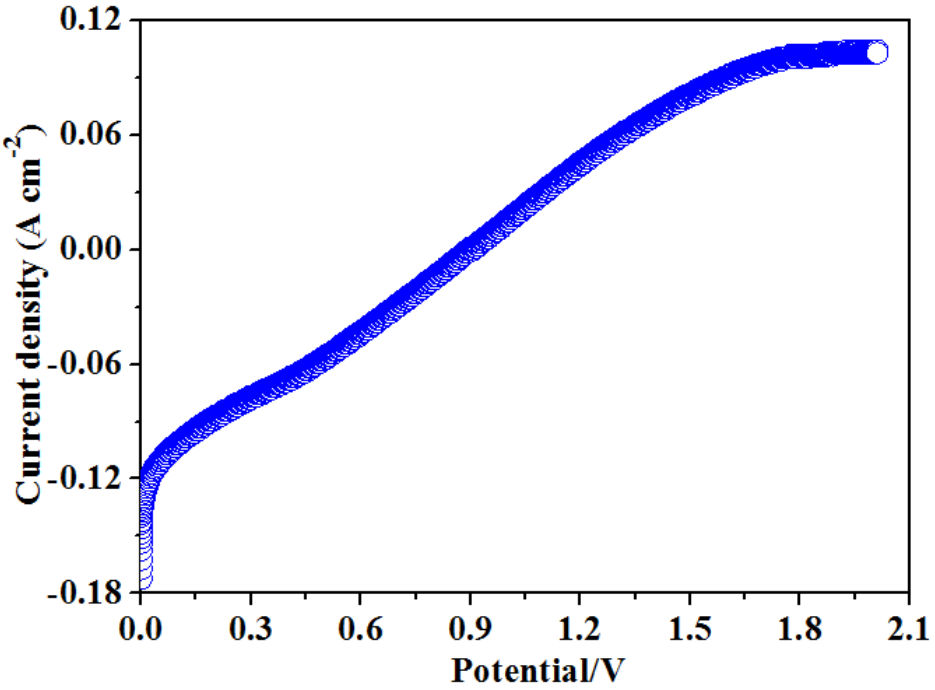

Fig.S7 AC impendence of the solid oxide electrolyzer based on Ni-SDC composite fuel electrodes for steam electrolysis with 4%H_2/Ar/3%H_2O fed to fuel electrode and oxygen electrode in static air at 800 ºC.

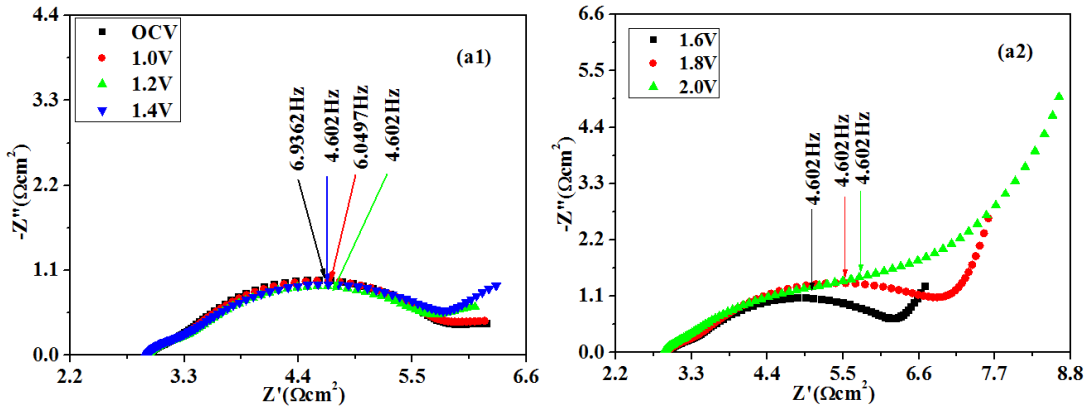

Fig.S8 (a) Short-term performance of the solid oxide electrolyzers based on Ni-SDC fuel electrodes for steam electrolysis (4%H_2/Ar/3%H_2O); (b) H_2 production and current efficiency based on Ni-SDC composite fuel electrodes.