Detonations are an extremely efficient, highly energetic mode of combustion. Detonation based propulsion systems have been desirable over the last decades given their potential for higher thermodynamic cycle efficiency. Current challenges in detonation driven propulsion systems for high speed propulsion applications stem from their restrictive reactive environment; low fuel residence time, temperature and pressure which can lead to ignition and flame stability issues. Understanding the ignition, propagation and stability limits to detonation waves is crucial to harnessing detonation potential for propulsion applications. In this article we present the experimental investigation of shock/flame coupling, detonation wave initiation and propagation in premixed Hydrogen-Air supersonic (Mach 5) flows. A Mach 5 high-enthalpy combustor is used to provide the premixed Hydrogen-Air stream targeted to match the Chapman-Jouguet (CJ) conditions for stable detonations. This works establishes three new distinct regimes of combustion in a premixed Mach 5 flow as a function of stagnation pressure and equivalence ratio: Shock-Induced Combustion, Unsteady Compressible Flames and Self-Exciting Deflagration-to-Detonation Transition (DDT). With rising national interest in reduced combustion emissions and detonation based propulsion for defense applications, the discovery and classification of these new combustion regimes allows for a possible pathway to develop and integrate detonation based combustion systems enabling hypersonic propulsion technology.