The thin film composite (TFC) polyamide membrane is the most common membrane used for reverse osmosis (RO) today. The method for making TFC membranes was invented in the late 1970s, and, remarkably, has changed little in 40 years: an aromatic polyamide thin film is formed in-situ directly onto a porous supporting membrane that provides mechanical integrity. The resulting membrane has exceptional rejection of salt ions from water. The inherent drawbacks of membranes made from this process (the formation of rough membrane with high fouling propensity, the lack of thickness and chemistry control, and substrate dependence) have not deterred the use of the approach. For four decades, engineers have instead adapted RO systems to accommodate the inherent weaknesses of TFC membranes. We present a new approach to making TFC polyamide membranes which retains their performance while enabling control of thickness and roughness in unprecedented ways. This additive manufacturing approach using electrospray enables control the thickness of polyamide thin films in as little as 4nm increments and results in films with roughness one-tenth that of conventional TFC membranes. Moreover, we demonstrate a dramatically reduced material usage in making our membranes when compared to conventional interfacial polymerization. The method is applicable to other polymer systems, potentially enabling the development of thin film composite membranes from polymers that are not adaptable to in-situ thin film formation using an interfacial polymerization approach.