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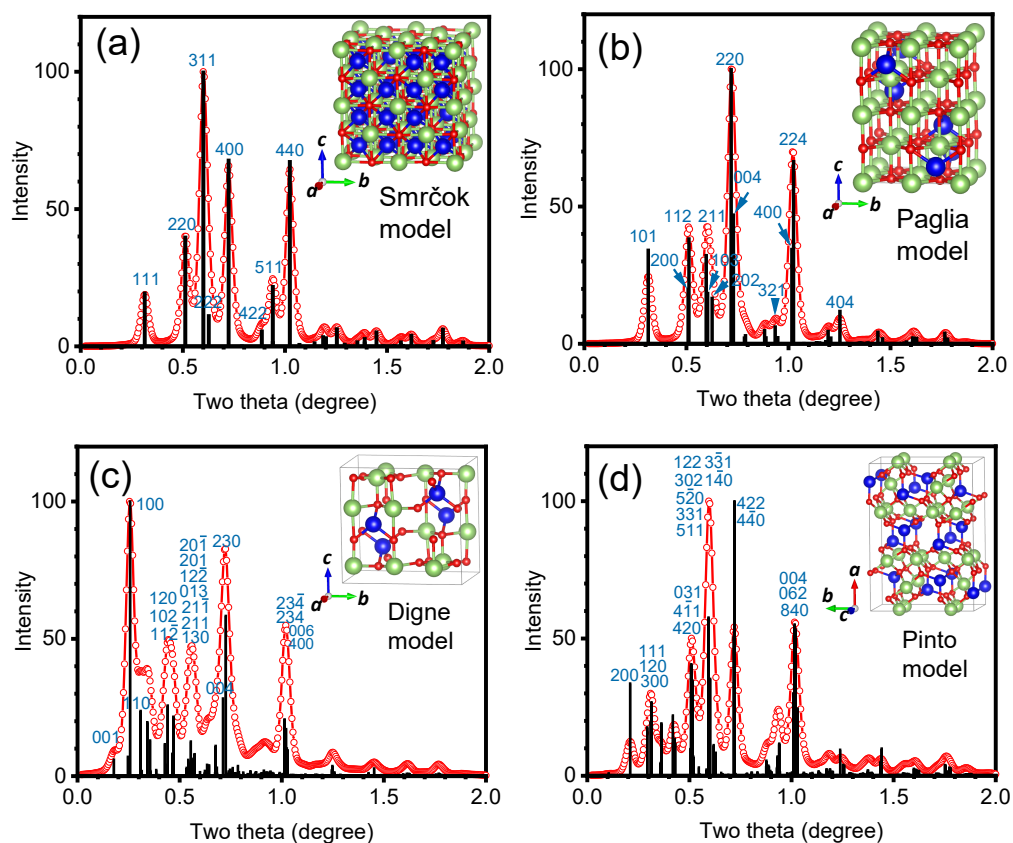


Fig. S1. Simulated electron diffraction patterns using cubic Smrčok model (a), tetragonal Paglia model (b), monoclinic Digne model (c), and monoclinic Pinto model (d). Structural models are inserted (green: octahedral Al; blue: tetrahedral Al; red: oxygen).

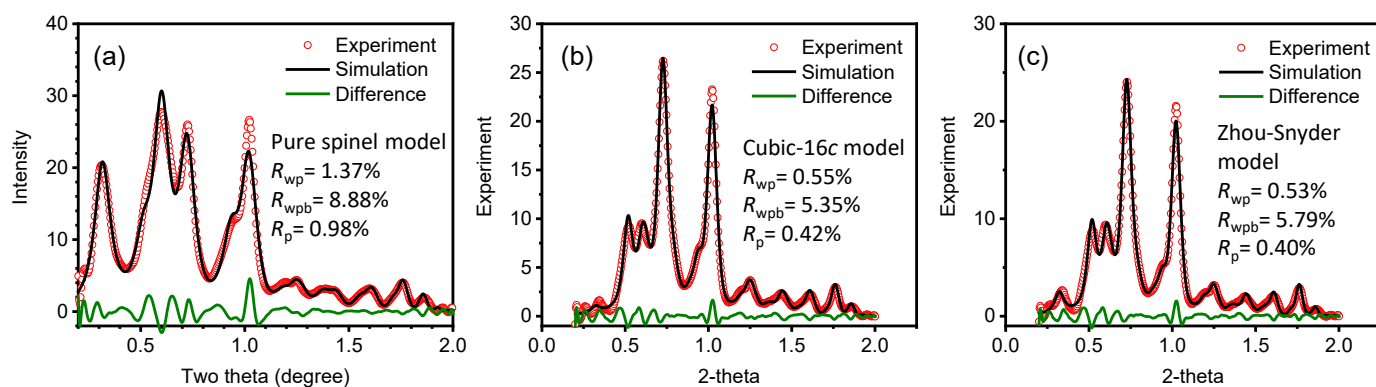


Fig. S2. Rietveld refinement of electron diffraction patterns from synthesized γ -alumina using different structural models: (a) pure cubic spinel model (Al at $8a$ and $16d$ sites); (b) Cubic-16c model by adding Al at $16c$ site to the spinel model (Al at $8a$, $16d$ and $16c$ sites); and (c) Zhou-Snyder model (Al at $8a$, $16d$ and $32e$ sites).

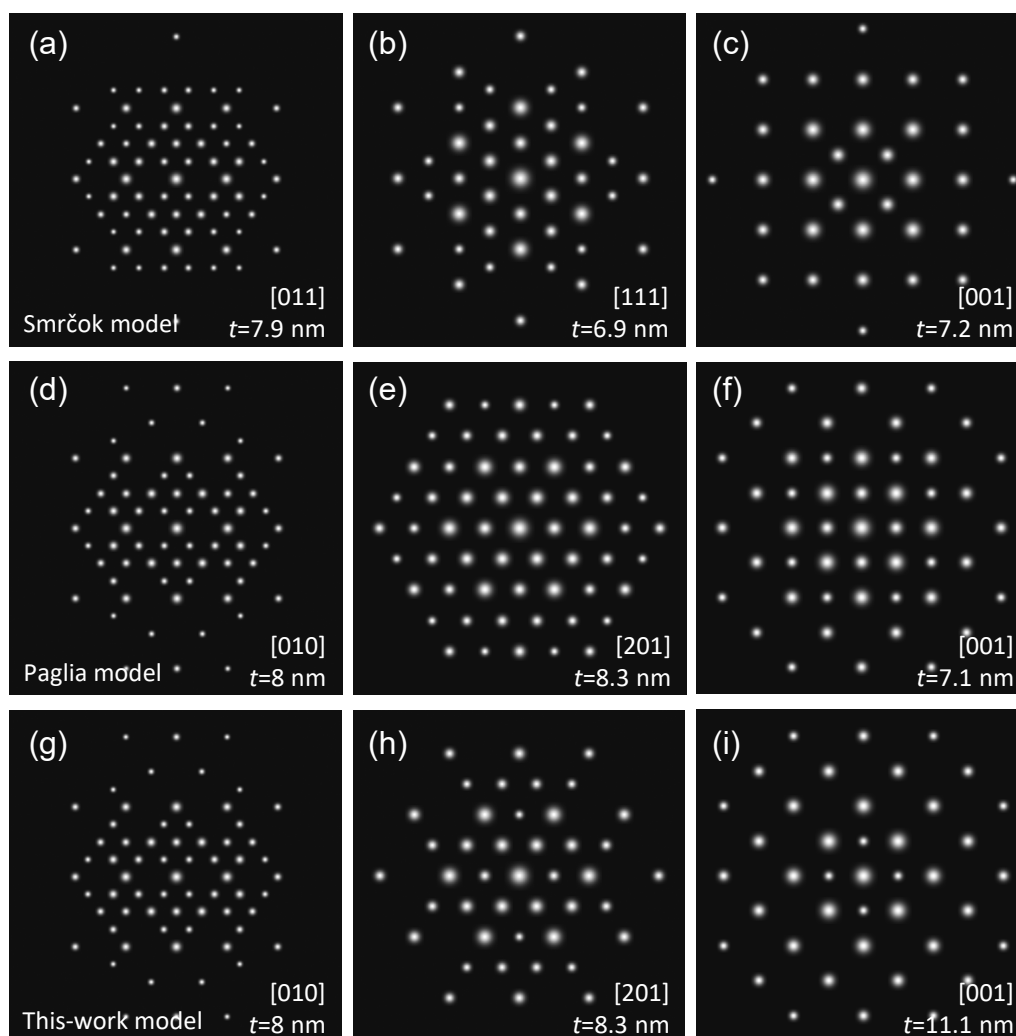


Fig. S3. Simulated single-crystal electron diffraction patterns along three major zone axes using Smrčok model (a–c), Paglia model (d–f) and this-work model (g–i). The thickness is indicated for each pattern.

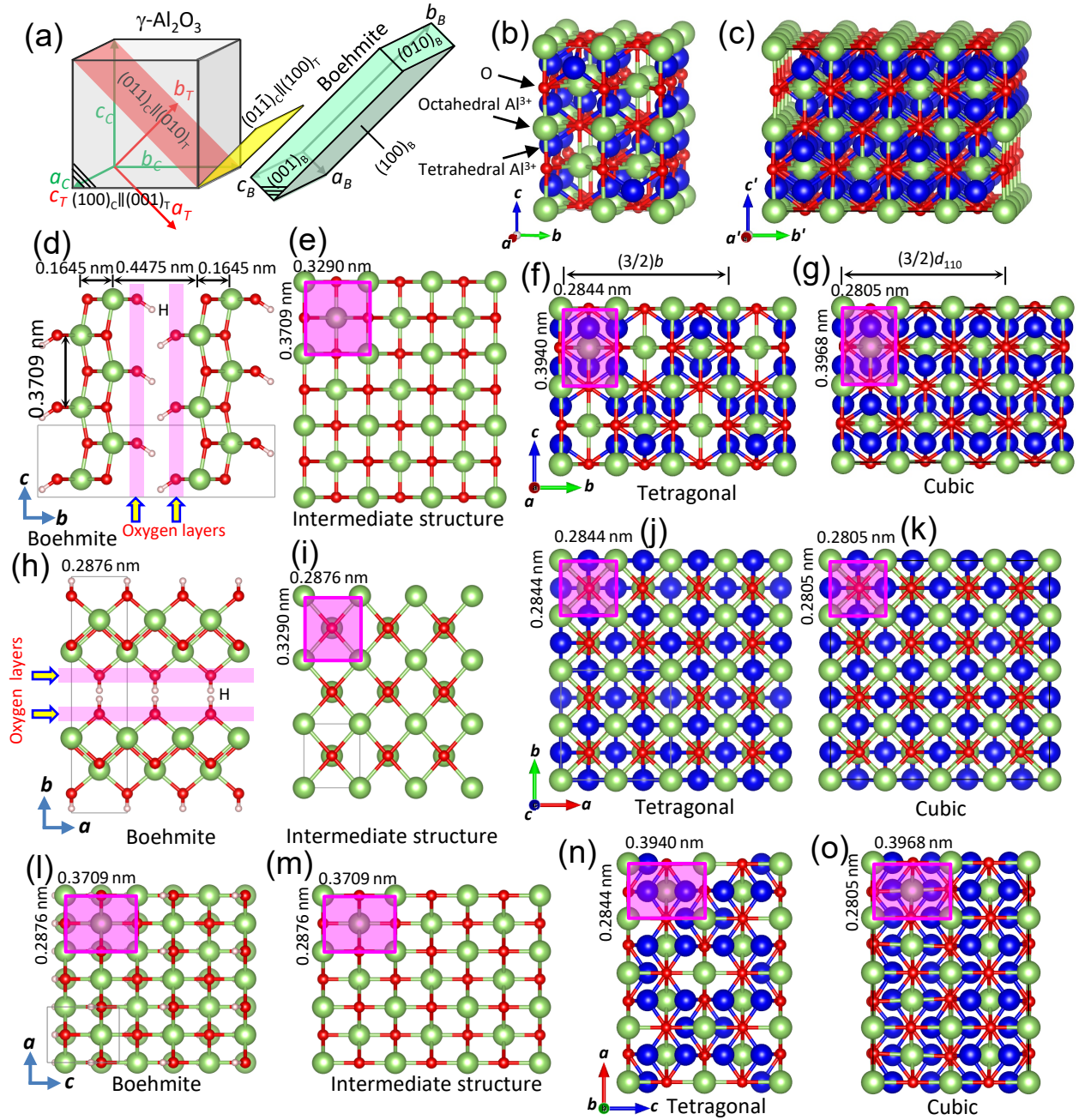


Fig. S4. Atomic projections. (a) Orientations between boehmite, cubic γ and tetragonal γ phases; (b) structural model of the tetragonal model proposed by this work; (c) structural model of cubic Smrčok model after conversion; (d–g) atomic projections along $[100]$ direction of boehmite, intermediate structure, tetragonal γ and cubic γ ; (h–k) atomic projections along $[001]$ direction of boehmite, intermediate structure, tetragonal γ and cubic γ ; (l–o) atomic projections along $[010]$ direction of boehmite, intermediate structure, tetragonal γ and cubic γ . For the γ phase structure, octahedral Al is shown in green, and tetrahedral Al in blue.