We describe a novel constitutive model of lung parenchyma, which can be used for continuum mechanics based predictive simulations. To develop this model, we experimentally determined the nonlinear material behavior of rat lung parenchyma. This was achieved via uni-axial tension tests on living precision-cut rat lung slices. The resulting force–displacement curves were then used as inputs for an inverse analysis. The Levenberg–Marquardt algorithm was utilized to optimize the material parameters of combinations and recombinations of established strain–energy density functions (SEFs). Comparing the best-fits of the tested SEFs we found $W_{par} = 4.1 \text{kPa}(I_1 - 3)^2 + 20.7 \text{kPa}(I_1 - 3)^3 + 4.1 \text{kPa}(\ln J + J_2 - 1)$ to be the optimal constitutive model. This SEF consists of three summands: the first can be interpreted as the contribution of the elastin fibers and the ground substance, the second as the contribution of the collagen fibers while the third controls the volumetric change. The presented approach will help to model the behavior of the pulmonary parenchyma and to quantify the strains and stresses during ventilation.