**Supplementary Figure 1: 3D Rendered images of the tri-layer hydrogel.** 3D rendering of the GelMA hydrogel (Left Panel) and the composite structure showing both the PAm and GelMA hydrogel layers (Right Panel) are shown for hexagon (A) and ellipse (B) GelMA patterns.

**Supplementary Figure 2: Effect of cell-dissolving solution on PAm hydrogel structures.** (A) Colored images show positions of beads in the reference state (red) and after the addition of cell-dissolving solution (green). Merged image shows mostly yellow color when the red and green images are overlaid, indicating minimal displacement of the fluorescent beads after cell-dissolving solution is introduced to the system. (B) Displacement field shows minimal displacement of ~1 or 2 pixels.

**Supplementary Figure 3: Contractile stresses of encapsulated cardiomyocytes as a function of time.** (A) The heat map of shear stresses applied onto the PAm hydrogel by the cell-laden GelMA hydrogel as a function of time (Day 2, 4, 7, and 12). The X- and Y-axis indicates the spatial location of the shear stresses while the negative and positive values indicate the left and right direction of the shear stresses, respectively. The color bars indicate shear stress values in Pascals (Pa). Note that the scale bars on the shear stress heat maps are different. (B) The corresponding peak stresses as a function of culture time. \*\* indicates statistically significant difference (p < 0.01) obtained from t-test. (C) The variability of the peak stresses from microtissues cultured for 7 days within different microfliuidics device. 3-5 microtissues were used to calculate the average peak stress from each chip. The bar plots show the average value along with the standard deviation.

**Supplementary Movie 1: Displacement of fluorescent nanoparticles in PAm hydrogel layer.** Movement of fluorescent green nanoparticles embedded within the PAm hydrogel corresponds with the contraction of the cardiomyocytes encapsulated within the ellipse-shaped GelMA structure.

**Supplementary Movie 2: 3D representation of fluorescent nanoparticle displacement.** The displacement of the fluorescent nanoparticles is tracked using particle image velocimetry. Red and blue indicate movement in the positive and negative vector direction, respectively.