Realization of near-infrared active Fano-resonant asymmetric metasurface by precisely controlling the phase transition of $Ge_2Sb_2Te_5$

Support information

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i. TEM of GST film with different baking temperature

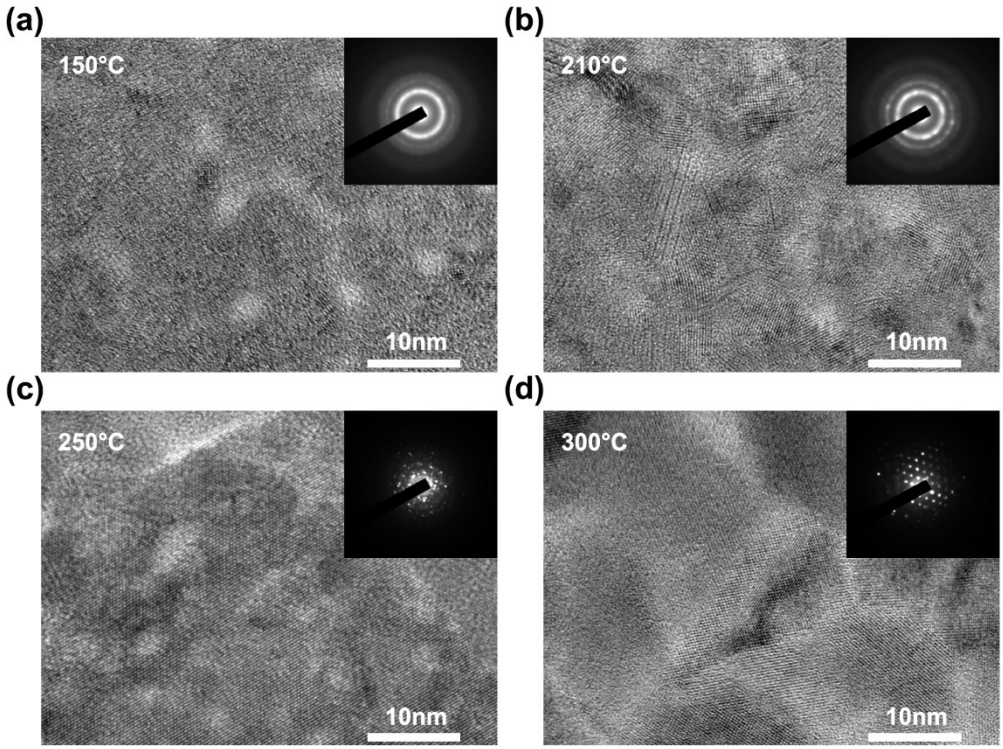

Fig. S1 TEM with the different ratio of crystallization GST. TEM results of 20 nm GST film baked at **(a)** 150°C, **(b)** 210°C, **(c)** 250°C and **(d)** 300°C**.**

In order to determine the phase transition temperature of the GST film, we have baked it at different temperature. Figure S1 has clearly shown that with the increase of the baking temperature, the stripes that represent the ratio of crystallization become more and more obvious. Furthermore, we can clearly observe the process of GST film from a-GST to FCC-GST and to HEX-GST. As shown in Figure S1a, there is a few of stripes appear in some area after the 150°C baking temperature. And most of the GST is still in amorphous state. As shown in Figure S1b, the number of stripes significantly increase with the increase of baking temperature. And it has clearly shown that the arrangement of atoms are FCC. In Figure S1c, it is obvious that we can see that there

are not only FCC-GST but also the HEX-GST. But the sample which has been baked at 300°C, HEX-GST becomes the main component of the film. The insets are the SAED (selected area electron diffraction) which can further determine the order of atoms. Note that, all the samples with different baking temperature are baked by accessories to eliminate the experimental errors caused by different baking conditions.

ii. Influence of thickness of GST and cap layer on resonance

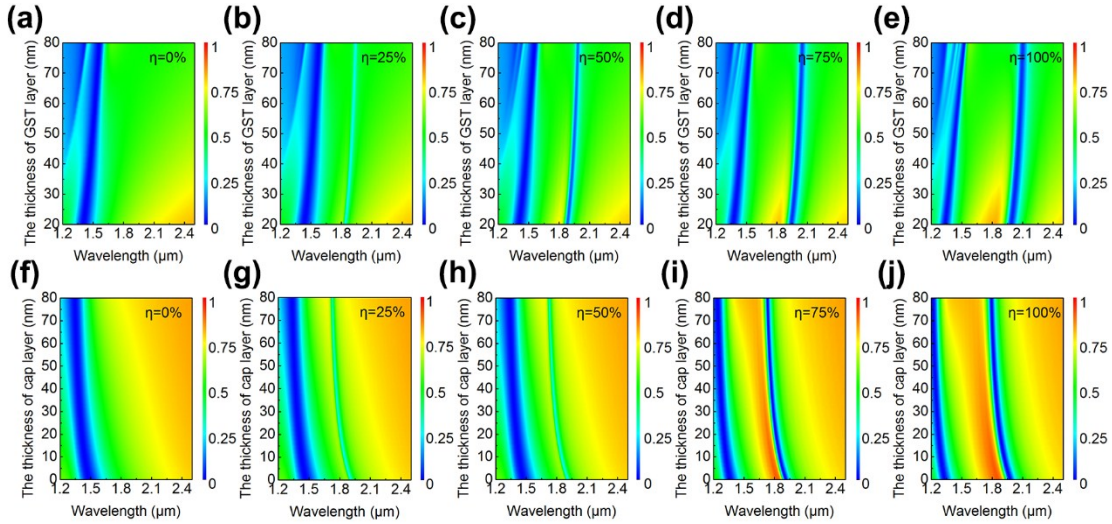

Fig. S2 The influence of GST layer and cap layer on resonance. The simulated influence of thickness of GST layer on the dipole resonance mode and Fano resonance mode with different asymmetry parameters **(a)** $\eta = 0\%$, **(b)** $\eta = 25\%$, **(c)** $\eta = 50\%$, **(d)** $\eta = 75\%$, **(e)** $\eta = 100\%$. The simulated influence of thickness of cap layer on the dipole resonance mode and Fano resonance mode with different asymmetry parameters **(f)** $\eta = 0\%$, **(g)** $\eta = 25\%$, **(h)** $\eta = 50\%$, **(i)** $\eta = 75\%$, **(j)** $\eta = 100\%$.

As shown in Figure S2, we have studied the relationships between the thickness of the GST layer and the resonance frequency with fixed thickness of cap layer. The frequency of resonances will red-shift with the increase of the thickness of GST layer. On the contrary, blueshift will occur when the thickness of cap layer increases. So, we are supposed to choose an appropriate thickness ratio between the GST layer and cap layer in order to optimize the performance of metasurface. Here, we are supposed to emphasize that the thickness of cap layer is fixed to 40 nm when the thickness of the GST layer is optimized, and the thickness of the GST layer is fixed to 20 nm when the thickness of cap layer is optimized.

iii. Transmittance metasurface with different asymmetry parameters varied with temperature

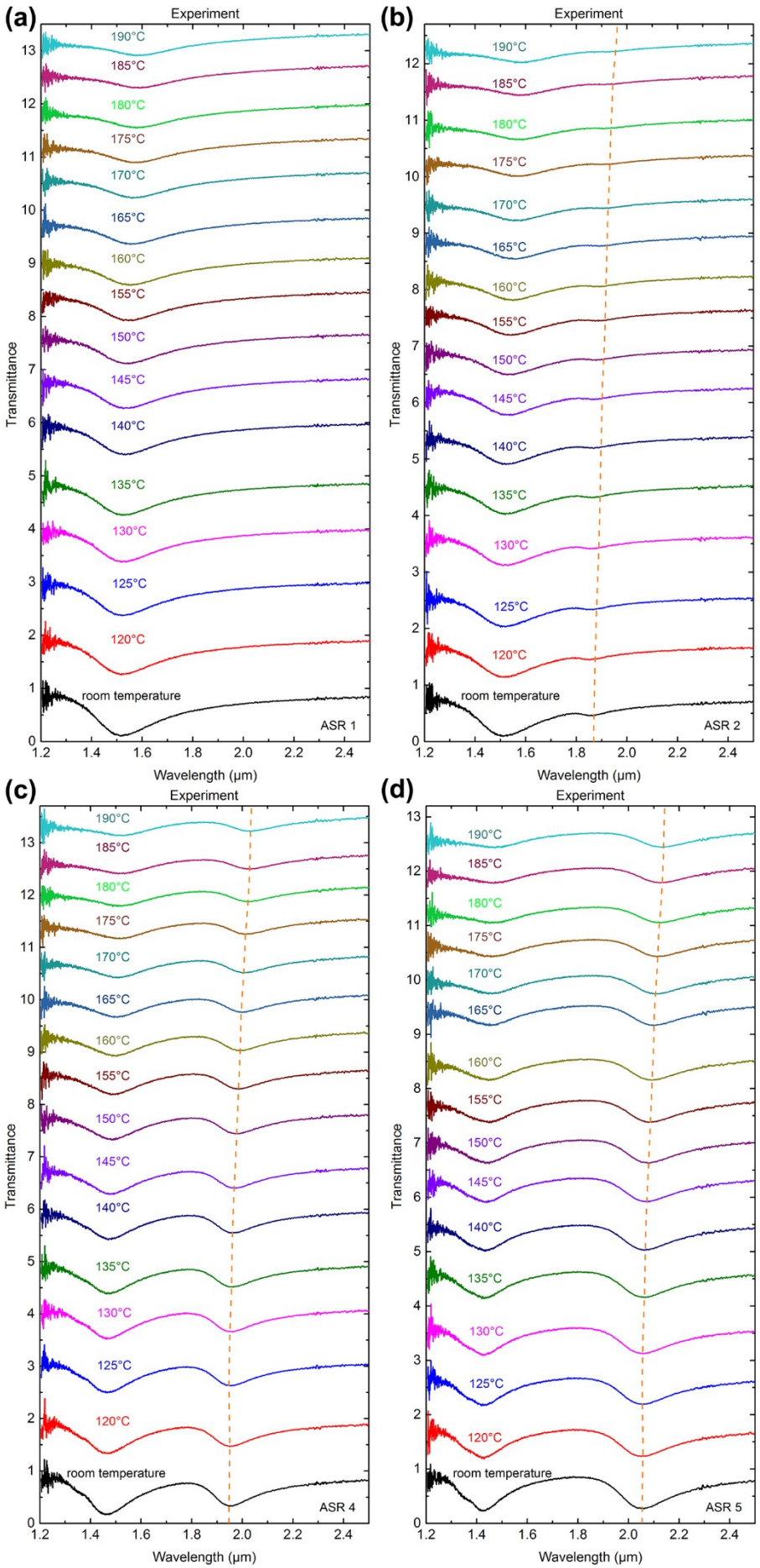
(a)
Experiment
190°C
185°C
180°C
175°C
170°C
165°C
160°C
155°C
150°C
145°C
140°C
135°C
130°C
125°C
120°C
room temperature
ASR 1
Transmittance
Wavelength (μm)
(b)
Experiment
190°C
185°C
180°C
175°C
170°C
165°C
160°C
155°C
150°C
145°C
140°C
135°C
130°C
125°C
120°C
room temperature
ASR 2
Transmittance
Wavelength (μm)
(c)
Experiment
190°C
185°C
180°C
175°C
170°C
165°C
160°C
155°C
150°C
145°C
140°C
135°C
130°C
125°C
120°C
room temperature
ASR 4
Transmittance
Wavelength (μm)
(d)
Experiment
190°C
185°C
180°C
175°C
170°C
165°C
160°C
155°C
150°C
145°C
140°C
135°C
130°C
125°C
120°C
room temperature
ASR 5
Transmittance
Wavelength (μm)

Fig. S3 The experimental transmittance spectra of the Fano resonances with different temperature. With in-situ baking accessories, the transmittance spectra from 120°C to 230°C in the steps of 5°C can be measured. **(a)** ASRR 1, **(b)** ASRR 2**,** **(c)** ASRR 4 and **(d)** ASRR 5 show the resonators with different asymmetry parameters.

As shown in Figure S3, we have investigated the transmittance with different baking temperature. The dips of Fano resonances marked by orange dash line will red-shift gradually with the increase of the baking temperature. And it clearly shows that the intensity of the resonances become weaker with the increase of the ratio of the crystallization of GST. Considering the stable time of GST after bake, 5 min is given t before we collect the transmittance of the sample. In this way, we are able to ensure the GST has baked completely at every detected temperature.

iv. Transmittances of asymmetry metasurfaces when FCC-GST transform into HEX-GST

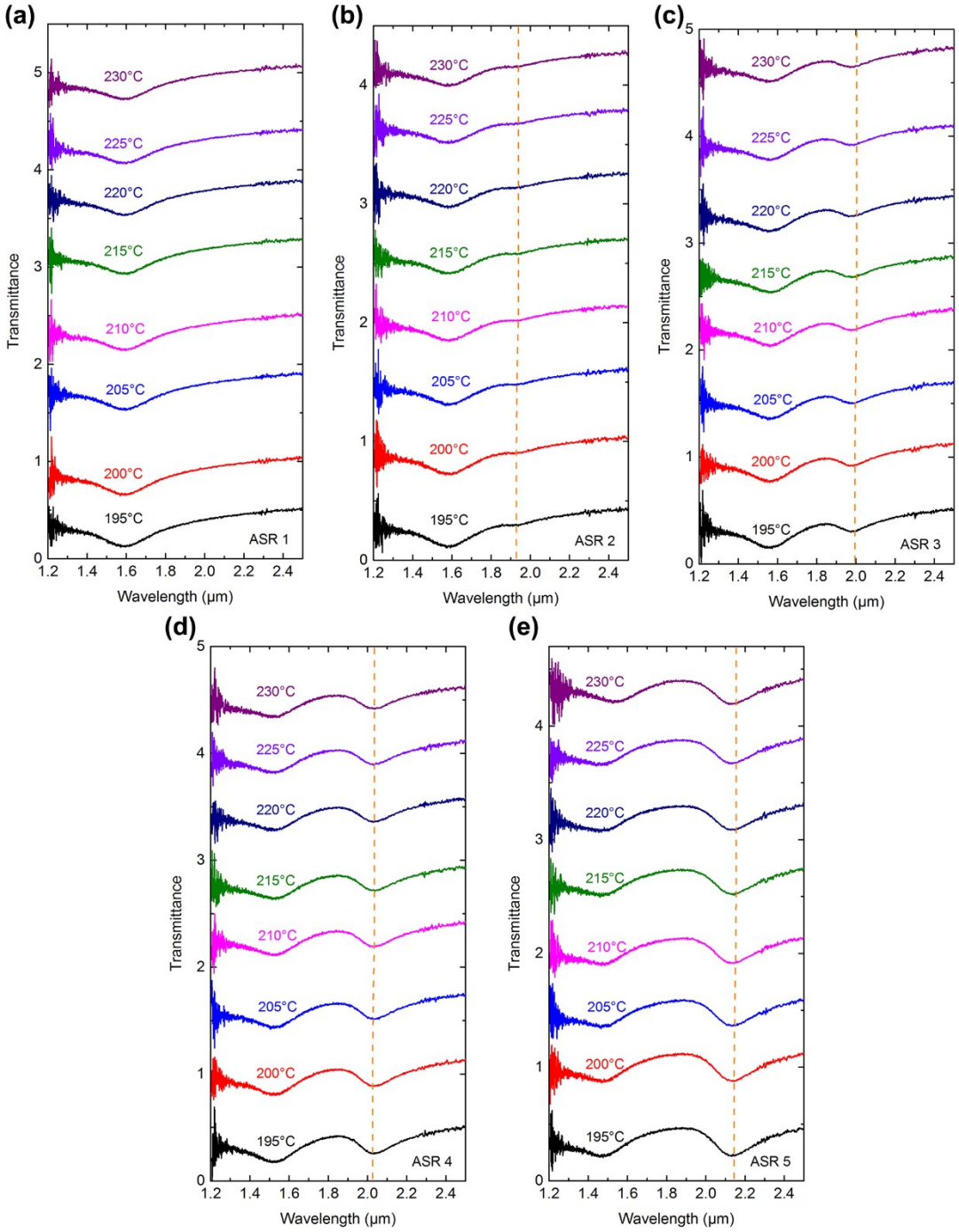

Fig. S4 The experimental transmittance spectrum of the Fano resonances when the phase of GST from FCC to HEX. The experimental transmittance spectrum when the functional layer GST from FCC-GST to HEX-GST with **(a)** ASRR 1**, (b)** ASRR 2**, (c)**ASRR 3**, (d)**ASRR 4 and **(e)** ASRR 5**.**

The results of XRD and TEM prove that a-GST has completely transformed into FCC-GST when the baking temperature reaches to 190°C. FCC-GST will transforms into HEX-GST with higher loss when the baking temperature continues to rise. We can conclude that the frequency of Fano resonances almost maintain, due to there is no significant difference between the real part of permittivity of FCC-GST and HEX-GST. The thing we need to emphasize here is that the dip of Fano resonance even blue-shift because the GST film will become thinner as the rise of the temperature. Simultaneously, the intensity of the resonance becomes weaker owing to the imaginary of permittivity HEX-GST has a dramatic increase compared to the FCC-GST.