We also notice that the propagation loss at 1550nm only decreases by ∼10% (from 0.31 to 0.28 dB/μm) after annealing. This can be qualitatively explained by the fact that a lower portion of the electric field intensity is located in the metal regions of the waveguide at 1550 nm compared to at 980 nm. Indeed, from our numerical modal calculation, it is found that only about 0.4% of the modal electric field intensity for the fundamental mode is in the metal at 1550 nm; whereas at 980 nm it's 1.1%. The difference for the second-order mode is similar, at 0.4% and 1.2% respectively.

To further investigate the effect of annealing temperature, we put the same waveguide back to the oven and heated it at 400 °C again for 18 hours. Compared to what we have obtained for 300 °C, no obvious difference is found, both from the top-view SEM image of the waveguide and from the measured propagation losses at the two wavelengths. Then we pushed the annealing temperature to 500 °C (also 18 hours). The top gold strip then undergoes severe distortion: the width of the gold strip at different positions experiences shrinking by different degrees. The nonuniformity of the width leads to increased propagation losses at both 980 and 1550 nm.

4. Conclusion

In conclusion, we have fabricated a plasmonic waveguide that resembles the microstrip transmission line. Though it can be treated as a variant of the metal-slot waveguide, it is potentially less lossy and has the advantage of simpler fabrication procedure. By using thermal annealing we are able to reduce the propagation loss of the waveguide by more than 50% at 980 nm. At 1550 nm, the effect of thermal annealing in reducing the loss is not significant, which can be explained by the lower portion of the modal electrical field located in the metal parts.

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