This paper introduces an effective approach for differentially exciting the rectangular dielectric resonator (DR), which lays a foundation for designing balanced DR bandpass filters (BPFs). By analyzing the properties of the DR, it can be found that the $TE_{11\delta}$ mode can be used for differential-mode (DM) operation while $TM_{11\delta}$ mode can be used for common-mode (CM) operation. Meanwhile, the two modes are split by drilling a hole at the center of the DR for enhancing the CM suppression of the proposed BPFs. According to the field distributions of the $TE_{11\delta}$ mode, two types of differential feeding schemes (namely, feeding schemes I and II) are investigated, where the $TE_{11\delta}$ mode can be well excited for constructing the DM passband. Two balanced BPFs based on the two feeding schemes are respectively designed, showing good DM bandpass response. A new asymmetric coupling route is introduced in the balanced BPF using the feeding scheme II to realize two transmission zeros in the lower and upper stopbands, improving the selectivity. For demonstration, it is fabricated and measured. The simulated and experimental results with good agreement are presented, which exhibits the best performance of the balanced BPFs so far, such as insertion loss (IL), selective skirt, and CM suppression.