In digital color imaging, the raw image is typically obtained through a single sensor covered by a color filter array (CFA), which allows only one color component to be measured at each pixel. The procedure to reconstruct a full color image from the raw image is known as demosaicking. Since the CFA may cause irreversible visual artifacts, the CFA and the demosaicking algorithm are crucial to the quality of demosaicked images. Fortunately, the design of CFAs in the frequency domain provides a theoretical approach to handling this issue. However, almost all the existing design methods in the frequency domain involve considerable human effort. In this paper, we present a new method to automatically design CFAs in the frequency domain. Our method is based on the frequency structure representation of mosaicked images. We utilize a multi-objective optimization approach to propose frequency structure candidates, in which the overlap among the frequency components of images mosaicked with the CFA is minimized. Then, we optimize parameters for each candidate, which is formulated as a constrained optimization problem. We use the alternating direction method to solve it. Our parameter optimization method is applicable to arbitrary frequency structures, including those with conjugate replicas of chrominance components. Experiments on benchmark images confirm the advantage of the proposed method.